MACHINE DESIGN

April 1949

FEATURING MACHINE DRIVES AND CONTROLS

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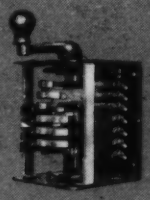
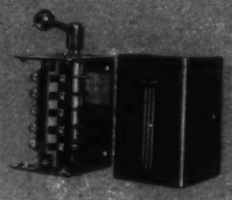
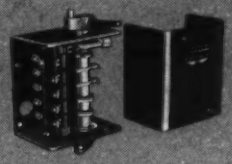


Primary resistor type reversing drum for use on small cranes

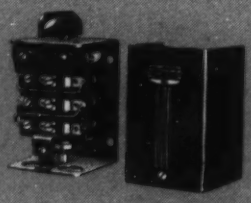


Surface mounted Size 1 reversing drum

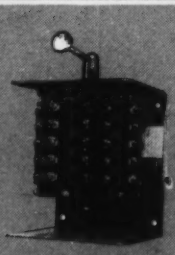
Two handle drum for 4 speed, full reversing motor



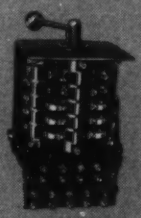
Lathe master switch, shipper rod operated



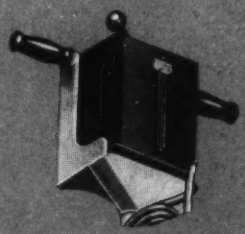
Self centering Size 0 reversing drum with tear drop handle



Four-speed non-reversing Size 1 drum



Star delta skeleton type drum for machine cavity mounting



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- **Other small motor driven processing equipment**

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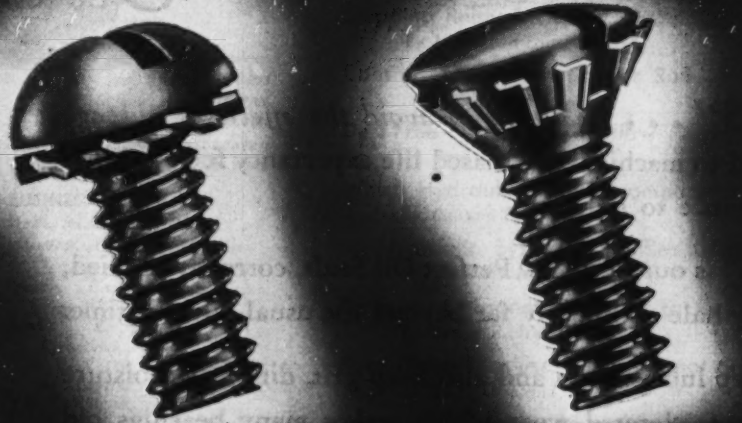

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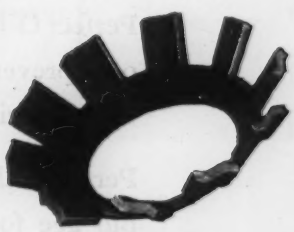

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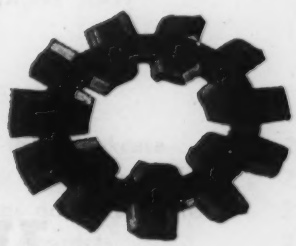

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This month's Cover: Symbolic portrayal of machine drives and their control envisioned by artist Kenneth Ives. Dependence of useful power upon machine elements is pictured by machine components encircling the path of a guided missile.

MACHINE DESIGN

Vol. 21—No. 4 **April, 1949**

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DESIGNING FOR PRODUCTION AND SALES · STYLING
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MD

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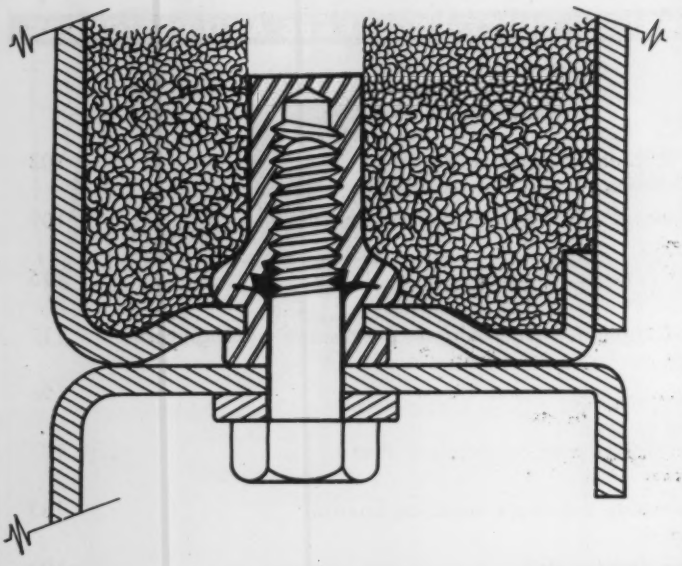

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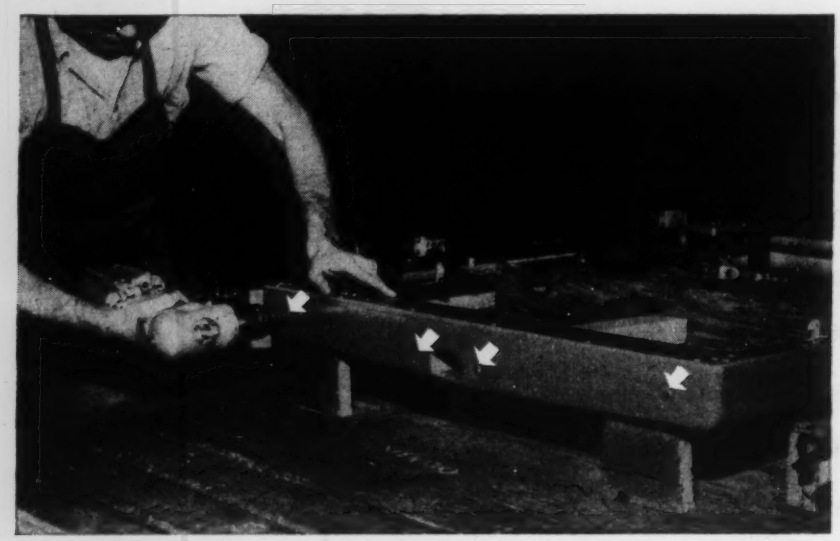

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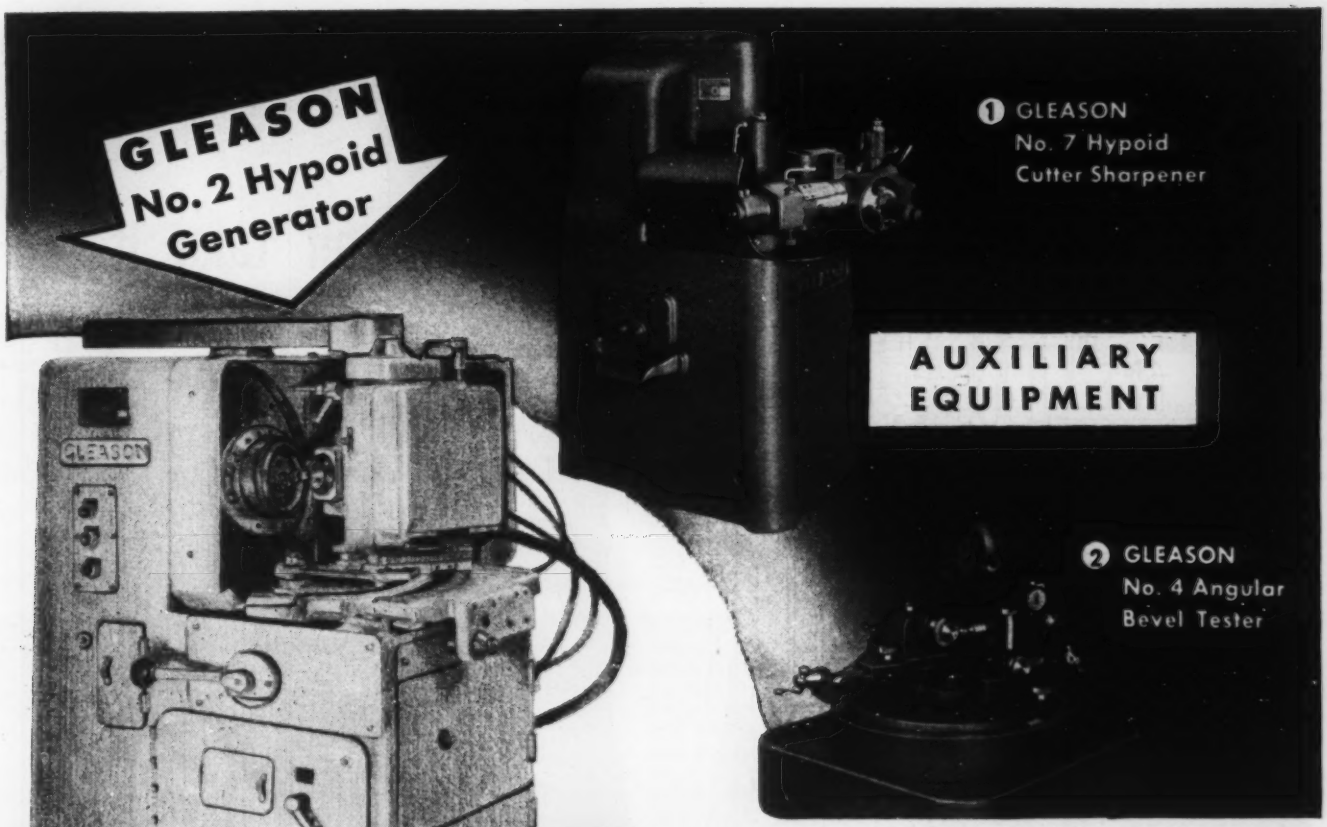

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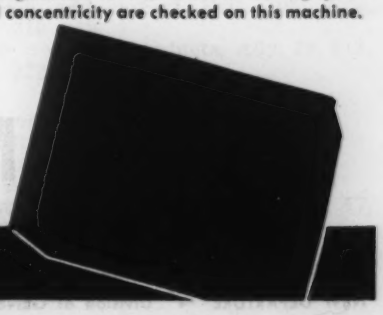
GLEASON No. 4
Angular Bevel Tester

② The Gleason No. 4 Anguar Bevel Tester can be used to either hand roll or power test bevel gears cut on this machine. Rolling qualities, tooth spacing and concentricity are checked on this machine.



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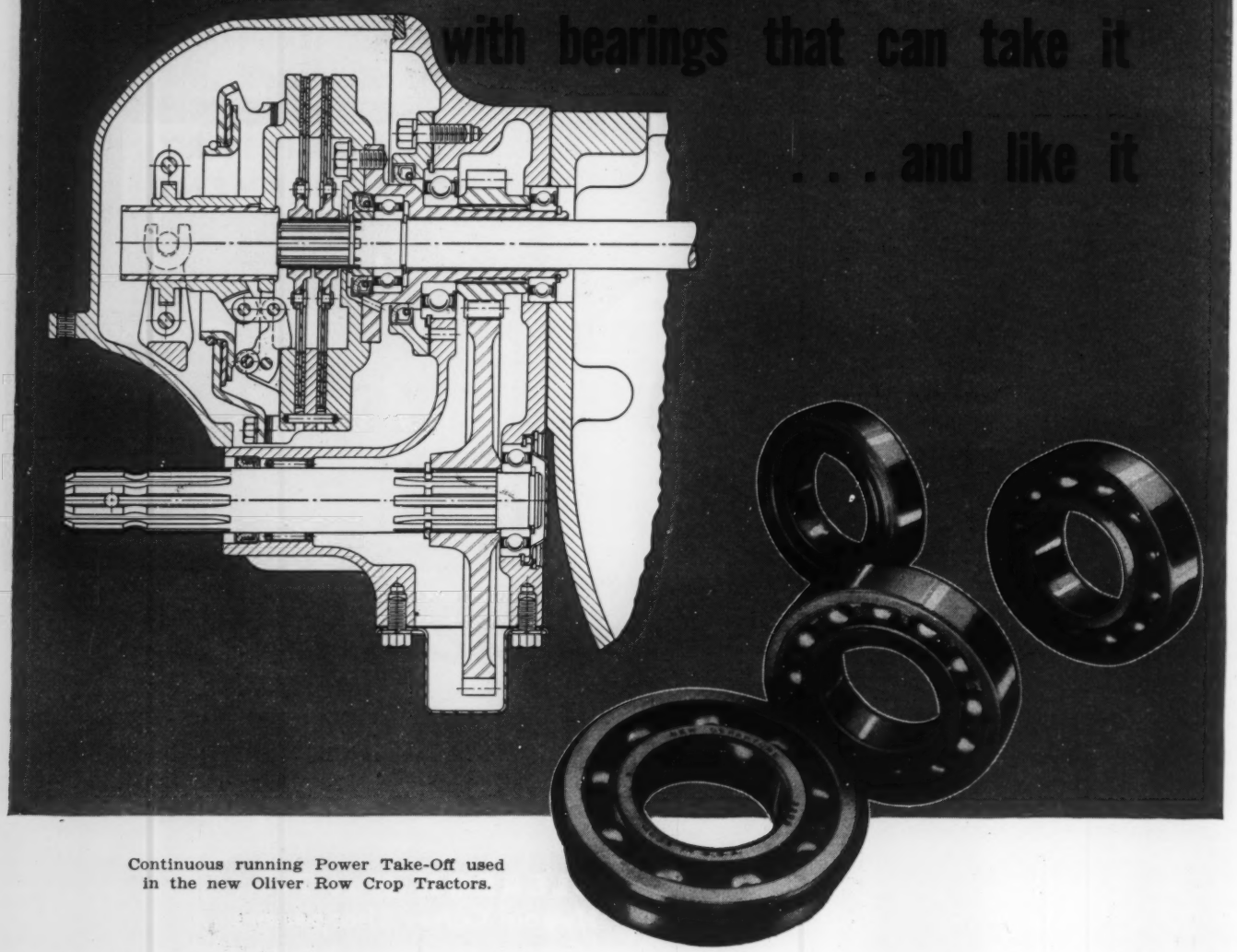

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37

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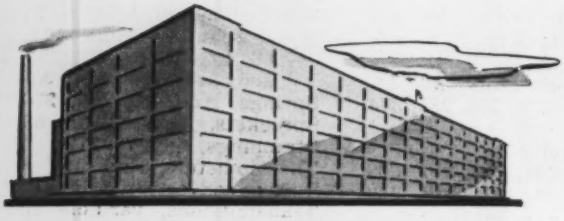

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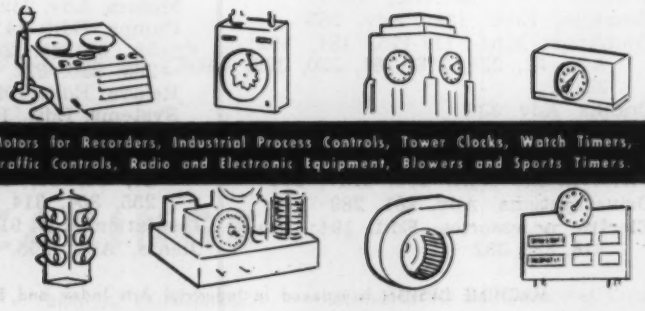
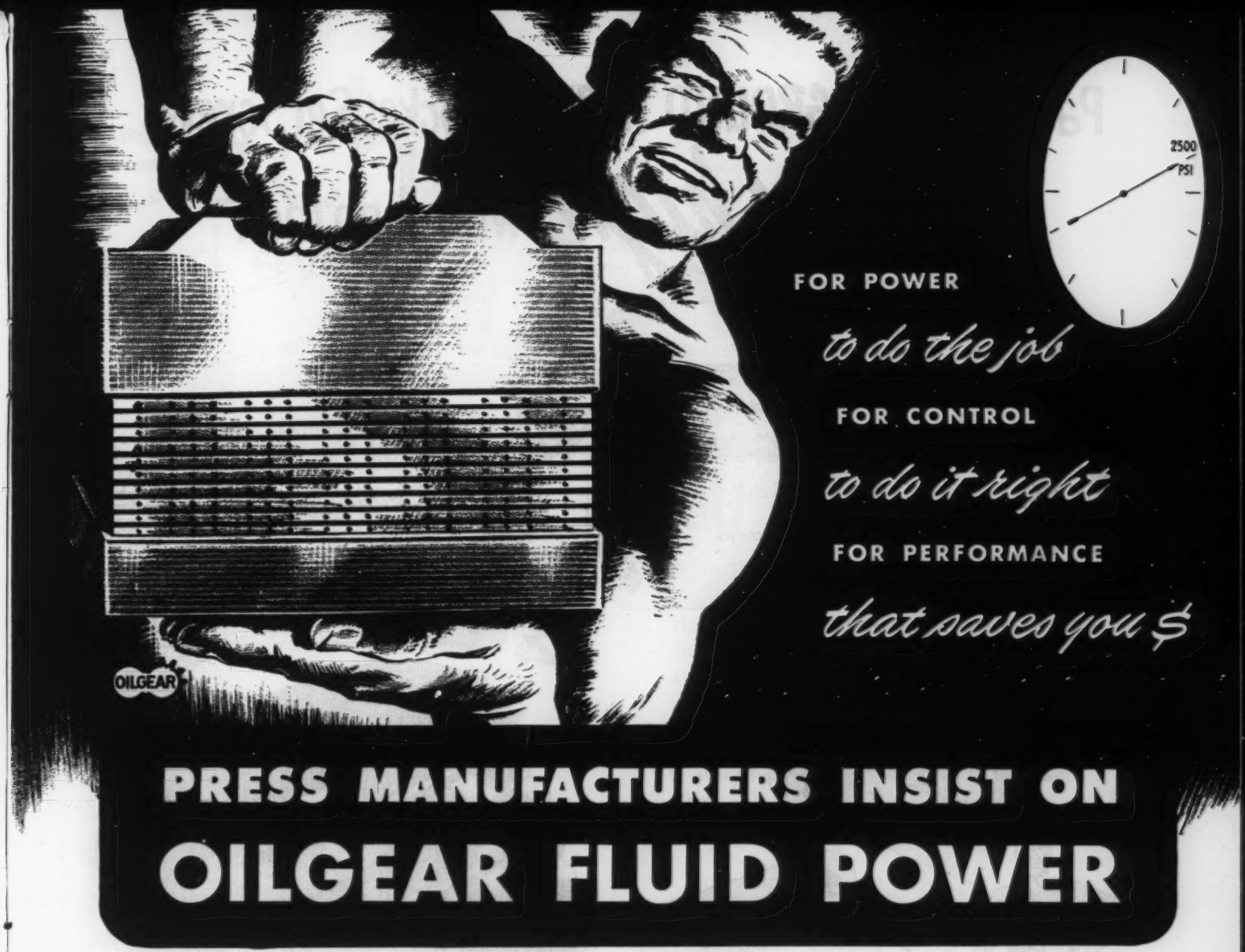
OFFICES: NEW YORK, PHILADELPHIA, CHICAGO



Motors for Recorders, Industrial Process Controls, Tower Clocks, Watch Timers, Traffic Controls, Radio and Electronic Equipment, Blowers and Sports Timers.



FOR POWER
to do the job
FOR CONTROL
to do it right
FOR PERFORMANCE
that saves you $

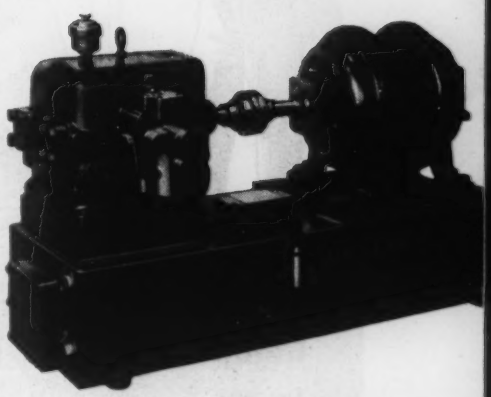
PRESS MANUFACTURERS INSIST ON OILGEAR FLUID POWER

Many outstanding manufacturers of heavy duty presses in every field have standardized on Oilgear tried and proven "Fluid Power" pumps, cylinders and valves.

Oilgear systems provide an adjustable working pressure to suit the work performed . . . a variable ram speed . . . automatic reduction of pump stroke and power input when pre-set pressure is reached . . . maximum pressure indefinitely without excessive heating or power loss. Low maintenance cost and high efficiency coupled with use of power only in proportion to the resistance of the work make their operation very economical. Simple, semi-automatic or full automatic controls are easily applied.

You get controlled, variable high speed for closing and opening press. You can vary the force to suit the material processed. You save a high percentage of power and reduce heat and wear during the curing time. Your Oilgear system will be simple, easy to install, and trouble-free. Investigate these and other operating values inherent in Oilgear pumps, cylinders, and valves. They have proven successful for over a quarter century on tough applications.

Write for data on typical Oilgear time, labor and money savings . . . on hot plate, molding, forming, straightening and other types of presses used throughout industry. THE OILGEAR COMPANY, 1568 W. Pierce St., Milwaukee 4, Wis.



Standard one-way variable delivery pump, type D.P. Automatic pressure unloading control, direct-connected electric motor, mounted on reservoir base.

Oilgear Fluid Power

Parker-Kalon GROUND THREAD Socket Set Screws are *aces high* with shop men

Compare! Write for Samples!

See why P-K Ground Thread Socket Set Screws speed assemblies, improve strength and safety. Thread grinding, once reserved for screws used in the finest precision equipment, now gives Parker-Kalon Socket Set Screws the accurate finish and faultless contour that mean faster assembly and more sales for your products. Write for samples today.

SEND FOR STOCK LIST NOW

PARKER-KALON® CORPORATION
200 Varick Street
New York 14, N. Y.

AVAILABLE THROUGH ACCREDITED DISTRIBUTORS IN EVERY INDUSTRIAL AREA

each and every Baldor MOTOR

is individually dynamically balanced and individually tested and checked

Shown at left: Dynamic Balancing process as applied in our plant to ALL rotors and armatures, assuring precise static and dynamic balance.

Shown below: Final testing, on a dynamometer, of a motor ready to be shipped. This test is applied to every type of motor produced in the Baldor plant.

- Every BALDOR Motor, regardless of type or rating, undergoes thorough testing (including various electrical and load tests) before leaving the plant.

That assures you that each BALDOR Motor ordered meets your exact specifications and that our reputation as manufacturers of Better Motors is maintained.

Baldor Motors are sold and serviced nationally by more than 200 Authorized Dealers.

BALDOR ELECTRIC COMPANY, ST. LOUIS DISTRICT OFFICES IN PRINCIPAL CITIES

ELECTRICAL MOTOR SPECIALISTS FOR MORE THAN A QUARTER CENTURY

NOW... there's a big change in this picture

And you see it in quicker P-K Self-tapping Screw deliveries

REMEMBER THIS PICTURE? We used it in an August, 1946 advertisement to illustrate the serious shortage of raw materials, a main reason why deliveries of P-K Self-tapping Screws were so slow.

Now, there's a big change. Supplies of steel wire are almost normal. Backlogs have been worked down. Stocks have been built up. As a result, on most sizes of screws, in all types, prompt deliveries are again being made.

Today, there is no longer any reason why any manufacturer need accept a substitute when he wants P-K Self-tapping Screws. Parker-Kalon Corporation. 200 Varick Street, New York 14, N. Y.

GOOD NEWS FOR ALL USERS OF PARKER-KALON SELF-TAPPING SCREWS

YOU'RE *O-K* WITH *P-K* ... THESE *EXTRAS* PAY

- ORIGINATORS OF SELF-TAPPING SCREWS
- ONLY COMPLETE LINE
- 35 YEARS' APPLICATION EXPERIENCE
- EXPERT ASSEMBLY ENGINEERING
- UNSURPASSED QUALITY CONTROL LABORATORY
- LARGEST PRODUCTION FACILITIES
- TOP-RATED DISTRIBUTORS EVERYWHERE

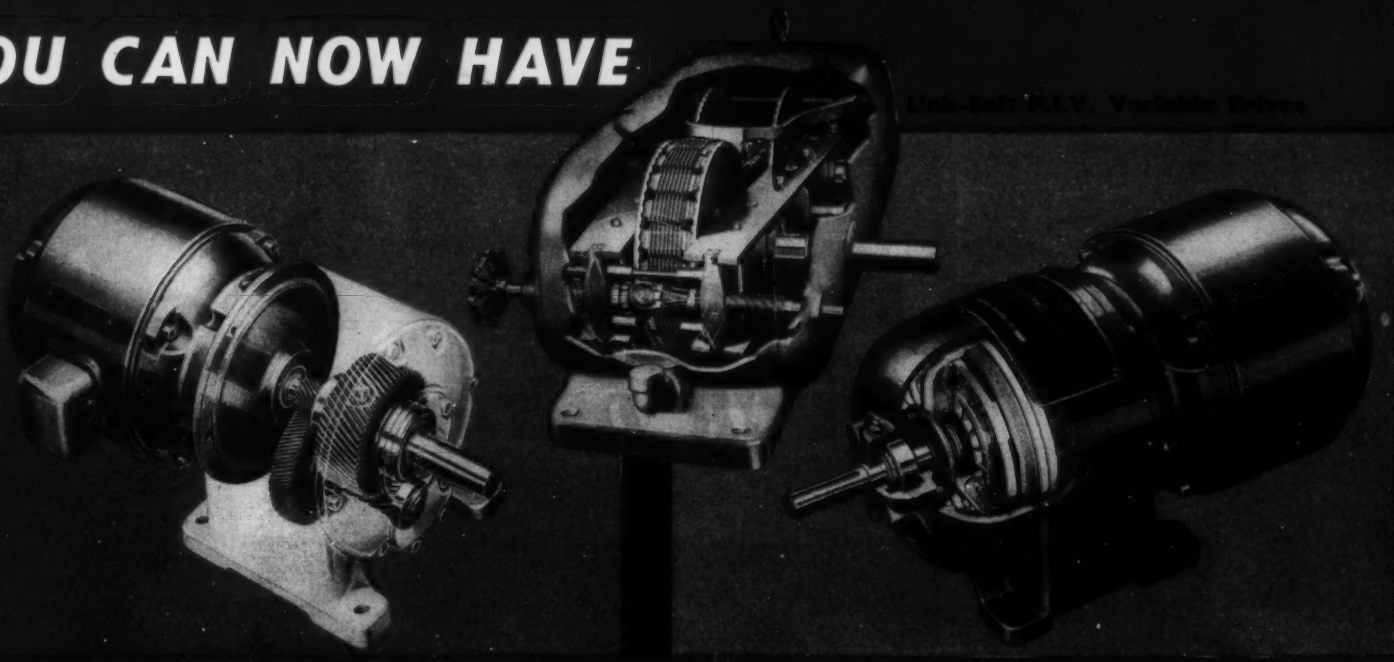
AVAILABLE THROUGH **P-K**® ACCREDITED DISTRIBUTORS

PARKER-KALON
Trademark
SELF-TAPPING SCREWS

FOR EVERY METAL AND PLASTIC ASSEMBLY

OTHER PARKER-KALON PRODUCTS: Cold-Forged Socket Screws, Wing Nuts, Thumb Screws Hardened Screwnails and Masonry Nails - Shur-Grip File and Solder Iron Handles Metal Punches - Damper Regulators and Accessories

YOU CAN NOW HAVE

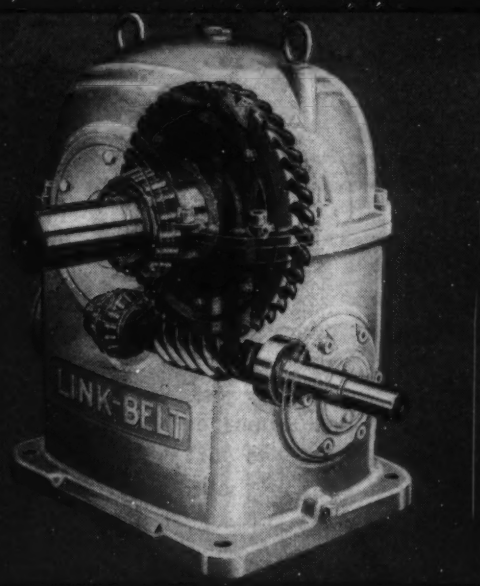


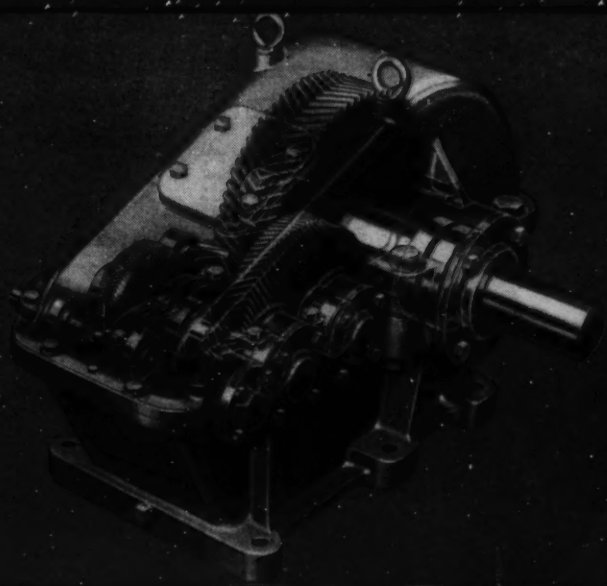
Link-Belt P.I.V. Variable Drives

Link-Belt Speedreducers

Link-Belt Hydrafluid Drives

IMMEDIATE DELIVERY ON





Link-Belt Worm Gear Drives

Link-Belt Herringbone Gear Reducers

LINK-BELT ENCLOSED DRIVES

YOU can increase machine efficiency by using Link-Belt Drives. The added efficiency of the proper drives for speed reduction, speed variation or other power transmission is available to you *at once*. Because Link-Belt manufactures a complete line, you can rely upon the unbiased advice of a Link-Belt Engineer as to the proper drive for your particular need. For prompt and reliable service, please call our nearest office.

LINK-BELT COMPANY Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities.

11,418-A

LINK-BELT

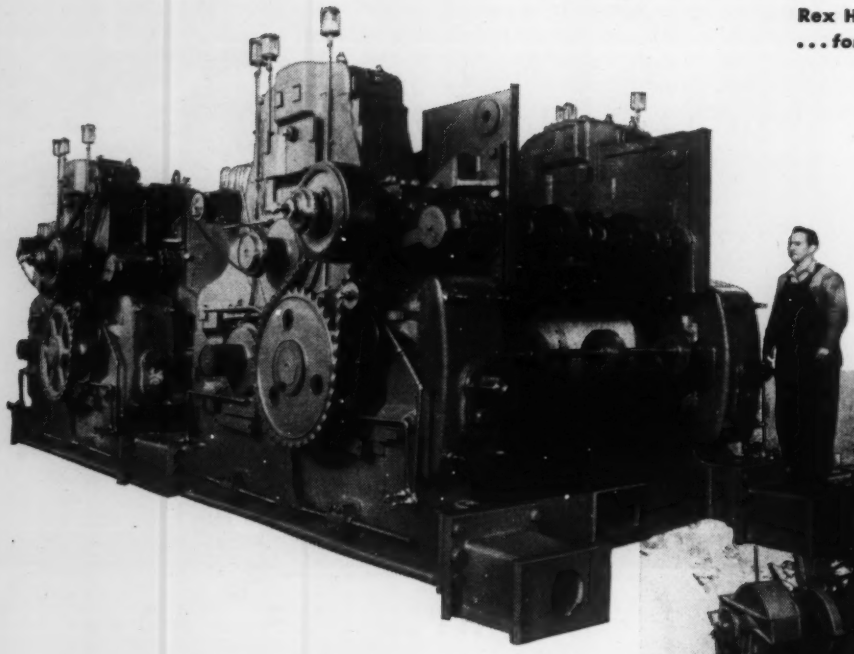
Power Transmission Machinery

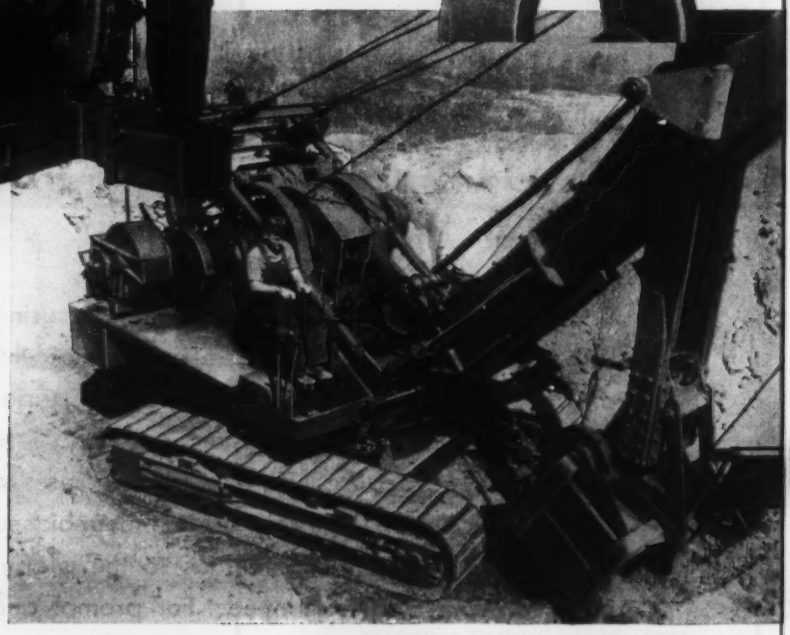
"THE COMPLETE LINE"

NEED MORE "DRIVE" IN YOUR DESIGNS?

Check Chabelco!

Rex Heavy Chabelco
. . . for heavy loads

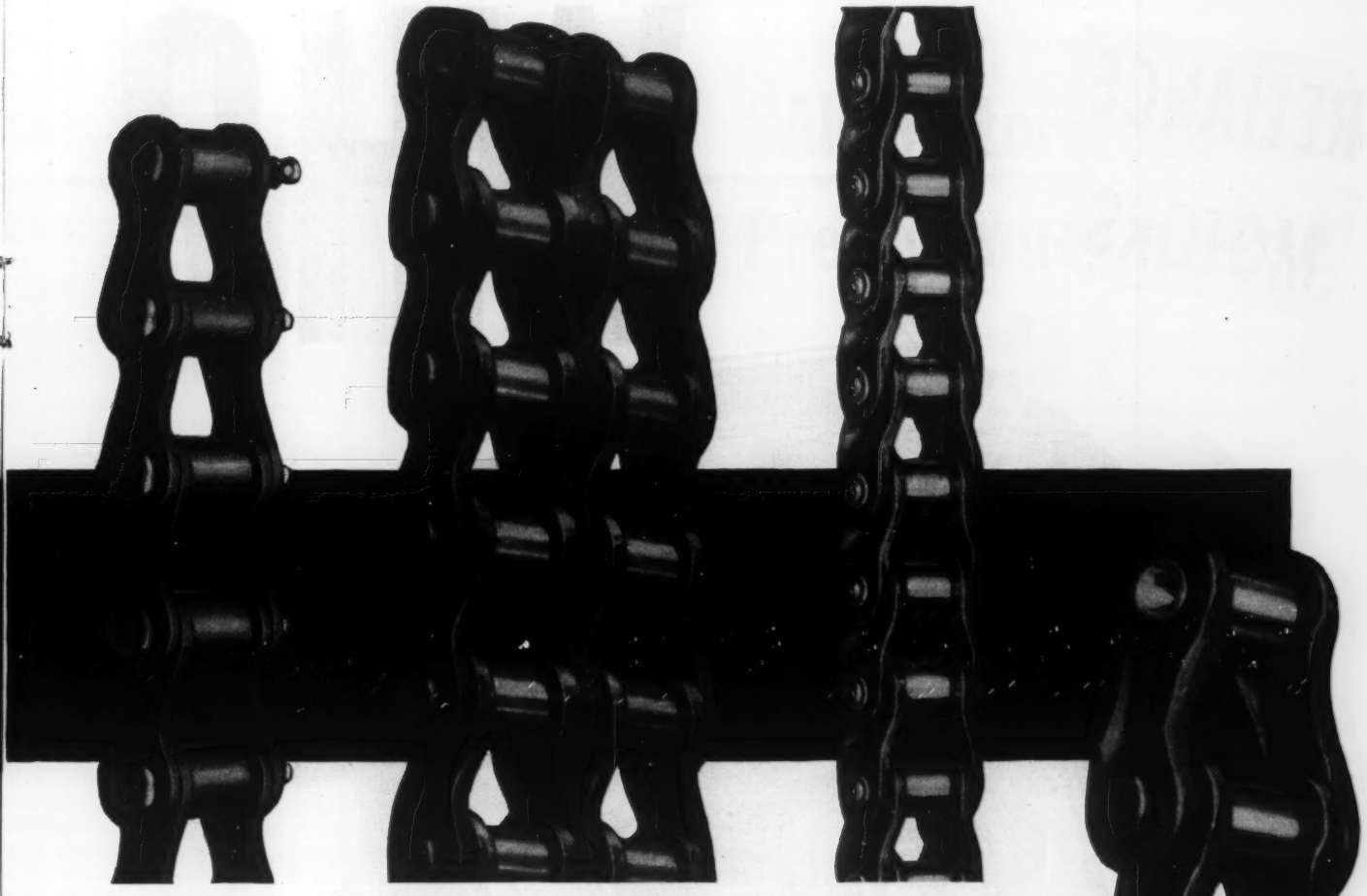




TYPICAL REX CHABELCO APPLICATIONS

Rex Chabelco Chains in this sugar mill deliver efficient service despite corrosive action of sugar juices and shock loads.

Rex Chabelco Chains are used on this shovel to assure efficient operation because of the severe shock loads and adverse operating conditions.



Rex Light Chabelco . . . ***for moderate loads***

Rex Universal Chabelco . . . ***for heavy loads at higher speeds***

Rex 3100 Series Chabelco . . . ***short pitch chain for high-speed service.***

IF YOU'RE designing equipment that must operate under heavy loads . . . that is subjected to severe shocks and stresses, the Rex Chabelco Line of Chains and Sprockets is "made to order" for you!

Specifically designed for drive service where loads are heavy and speeds moderate, these husky steel chains deliver more H.P. per dollar . . . are low in initial and operating costs. Often a Rex Chabelco Chain, in single or double strand, will handle loads that would require triple or quadruple strands in other types of chain.

Where service is exceptionally severe . . . where equipment must operate under conditions of dirt, dust and temperature extremes, a Chabelco Chain will keep going when other driving mediums would soon fail. Designed-in clearances between working parts enable it to operate efficiently under these conditions and to accommodate minor misalignments.

Many sizes of standard Rex Chabelco Chains and Sprockets are becoming increasingly available. For all the facts on how they can help you put more "drive" in your designs at the lowest overall cost, call your Rex Field Office or write Chain Belt Company, 1643 West Bruce Street, Milwaukee 4, Wis.

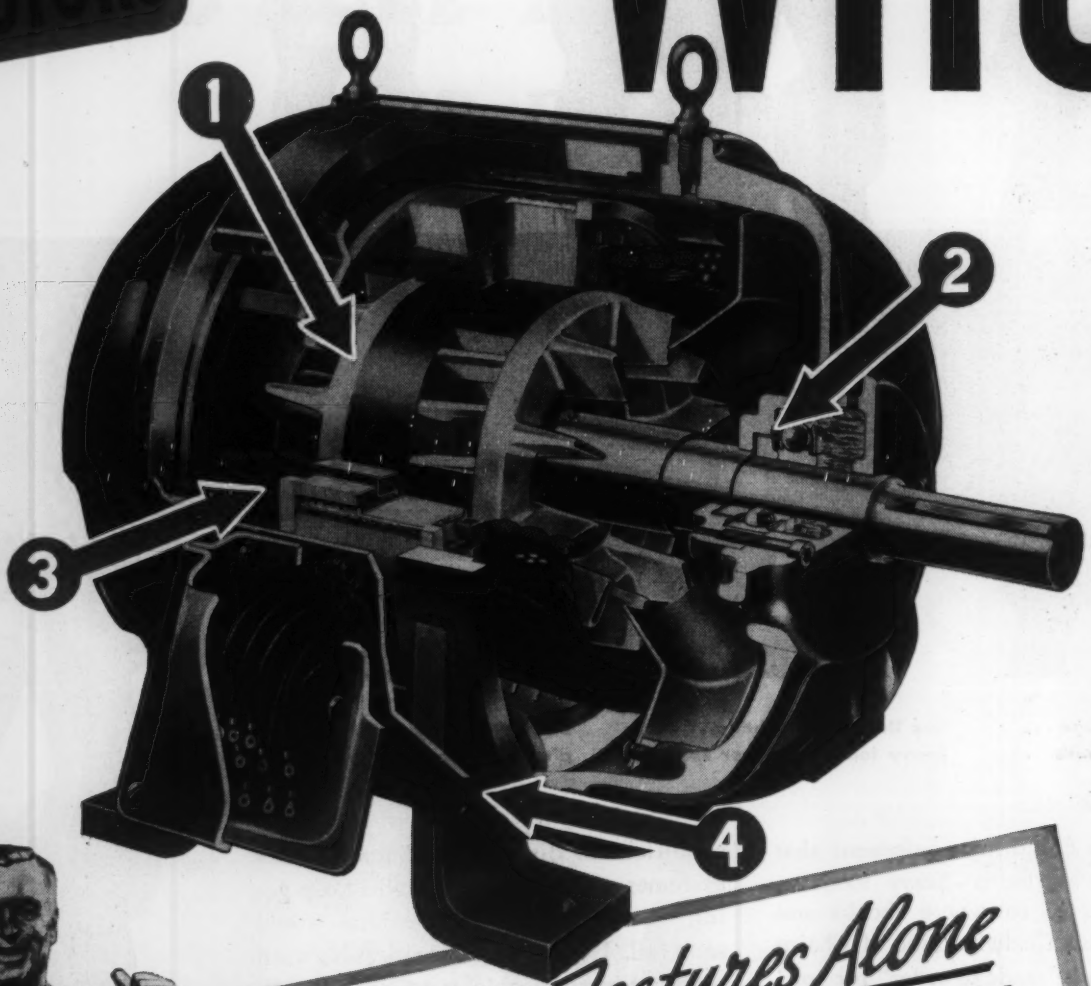
Rex Champion Chabelco
. . . for extra heavy loads

CHAIN BELT REX COMPANY

DRIVE AND CONVEYOR CHAINS

RELIANCE
Precision-Built
MOTORS

WHO



These Four Features Alone

Make RELIANCE the motor for you!

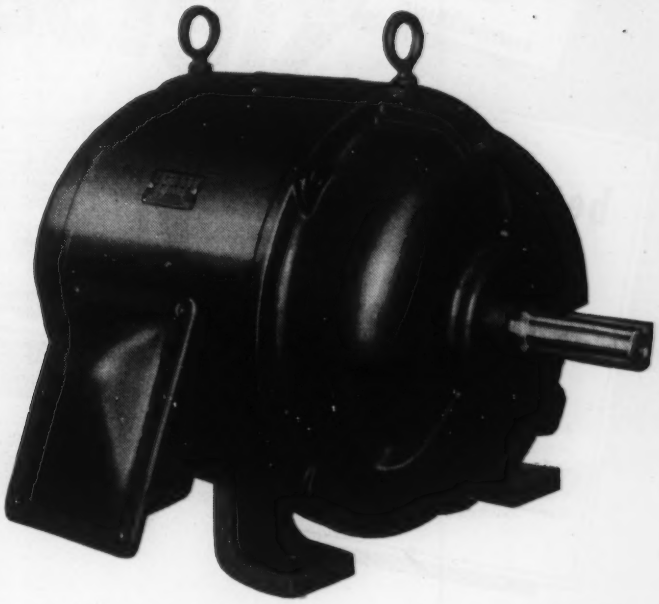
1 **Dynamic Balancing—Precision Fits**—Every motor is dynamically balanced by skilled technicians using latest electronic-principle equipment. Machining of parts to exacting tolerances guarantees precision fits throughout. Result: a smoother-running, longer-lasting motor!

2 **No Lubrication Worries**—Precision Bearing Mounting, with double-shielded ball bearings, assures longer bearing life under all normal conditions, whether overgreased, undergreased or not greased at all. *"You can't grease 'em wrong!"*

3 **Reli-X Insulation** furnishes a new high in the protection of stator windings. Selected materials, exclusive methods and new continuous-sequence applications make this the *unfailing* insulation!

4 **Steel for Strength**—Steel construction, with electrically welded joints, combines maximum strength with minimum weight.

SAYS "All Motors are Pretty Much Alike?"



RELIANCE *Precision-Built* MOTORS

...are made *better* to deliver

DEPENDABLE POWER-LONGER!

Reliance has a way of building motors that must be seen to be fully appreciated. Any time we can take a motor user through the modern plants where Reliance *Precision-Built* Motors are made, we can be reasonably sure of another good Reliance customer. We would be delighted to have you make this visit. But if it isn't practical, call in your nearest Reliance representative and *see* the convincing facts he can show you on the precision methods that produce these truly superior motors.

Sales Representatives in Principal Cities

HOW TO SELECT THE RIGHT MOTOR

Here's a book which digests all the information you should have in selecting the motor that's just right for any job. New torque and current standards recently adopted by the National Electrical Manufacturers Association for A-c. motors are tabulated and explained. And these are further supplemented by more detailed performance data on Reliance *Precision-Built* Motors. Write today for this important new Motor Data—Bulletin B 2101.

RELIANCE ELECTRIC AND ENGINEERING CO.

"Motor-Drive is More Than Power" • 1079 Ivanhoe Road, Cleveland 10, Ohio

BRUNING BW WHITEPRINTER 93

VOLUMATIC MODEL

Now *all* your departments can handle their copying jobs with a single versatile machine: the Bruning Whiteprinter, Volumatic Model 93. This brand new machine at last provides you the necessary volume and high speed (up to 105 sq. ft. per minute). At the same time, through simpler operations and less wastage, it reduces copying costs.

The Volumatic produces sharp, highly legible copies of engineering drawings, documents, or *anything* that is printed, drawn, written, or typed on a translucent medium. It copies charts, plats, letters, invoices, financial reports—and many other items. Its operation is so simple that a girl can learn to run it in less than an hour.

The Volumatic takes cut sheets or roll stock with equal facility. It produces sharp BW Prints from post card size up to 42 inches wide and of unlimited length. You can have light, medium, or card-weight BW Prints; BW Prints on tinted stocks; BW Prints on film or cloth; or BW Prints with colored lines. BW Prints are delivered front or rear, neatly stacked.

CHECK THESE BW ADVANTAGES

No vents or exhaust fans: The Bruning Model 93 is completely odorless . . . can be used anywhere in the office without the slightest offense.

No plumbing connections: There are no pipes to connect, no water to supply or drain away. The Model 93 is mounted on casters, is moved where needed.

Built-in transformer: The Model 93 is the first large volume whiteprinter which protects you against voltage fluctuations common to power lines. Assures longer lamp life, more uniform prints, as well as savings on BW Materials.

Uniform developing: Both sides of the print receive a thin, measured film of BW Developer Solution at once. This assures flat prints, never under- or over-developed.

Send today for full information. Let us send you a file of literature describing the new BW Volumatic Model 93 and other Bruning Whiteprinters, and the BW Mediums you can use with them. See for yourself the extreme versatility, economy, and speed of these machines. There is no obligation.

Other Bruning Products you should know about

Drafting Machines • Sensitized Papers & Cloth • Tracing Papers • Erasing Machines Drafting Room Furniture • Slide Rules Surveying Instruments • and many others.

Charles Bruning Company, Inc.

4726-34 West Montrose Avenue, Chicago 41, Ill.

New York • Newark • Boston • Pittsburgh • Chicago • Detroit
Cleveland • Milwaukee • St. Louis • Kansas City, Mo. • Houston
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AMERICA'S MOST CRITICAL BUYERS SPECIFY

FRACTIONAL HORSEPOWER GEARING

The Roberton Division of King Pneumatic Tool Co., Chicago, specified G.S. Gearing exclusively for their new ROBERTON Electric HEDGE TRIMMER pictured here.

WHEREVER dependable, *really rugged* service is required, that's where you'll usually find Fractional Horsepower Gearing by G.S.! The superior excellence and the almost uncanny *uniformity* of G.S. Small Gearing has now become practically legendary among particular buyers all over our country. Year after year G.S. Small Gears are used for old products as well as many remarkable *new* applications such as the one illustrated on this page. The secret of G.S. quality lies in more than thirty years of intensive specialization, "years of doing ONE THING *consistently better*"! If you need *quantities* of *better, more uniform* Small Gearing, by all means make use of our highly developed "know-how" and facilities. Without obligation let a skilled G.S. Engineer give you ideas, suggestions and cost estimates. Write or phone today!

SEND FOR *our 4 page catalog bulletin illustrating and describing many different types and applications of G.S. Small Gearing. It may offer valuable suggestions and ideas you can use. Write today.*

GEAR Specialties

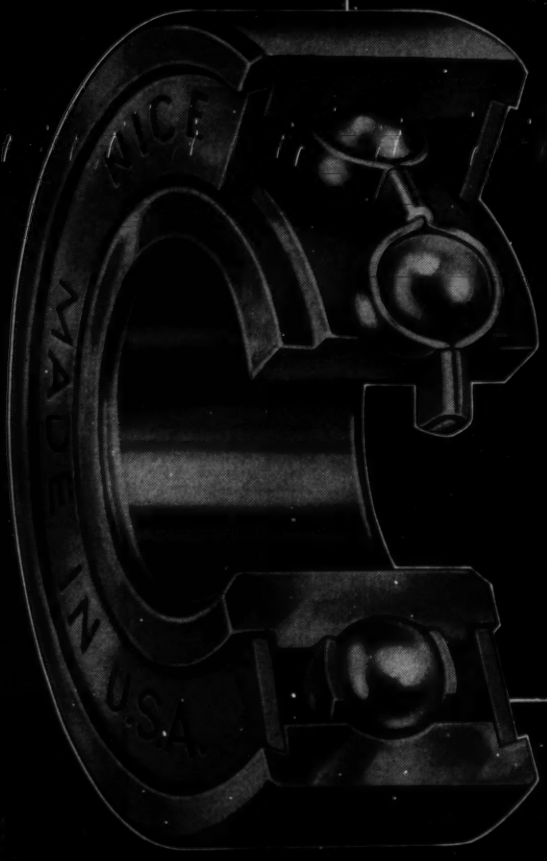
Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

2635 WEST MEDILL AVENUE · CHICAGO 47, ILLINOIS

MEMBER OF AGMA

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

Have you given NICE a chance to Quote?



STANDARD and SPECIAL BALL BEARINGS
Since 1902

WRITE FOR
CATALOG NO. 125

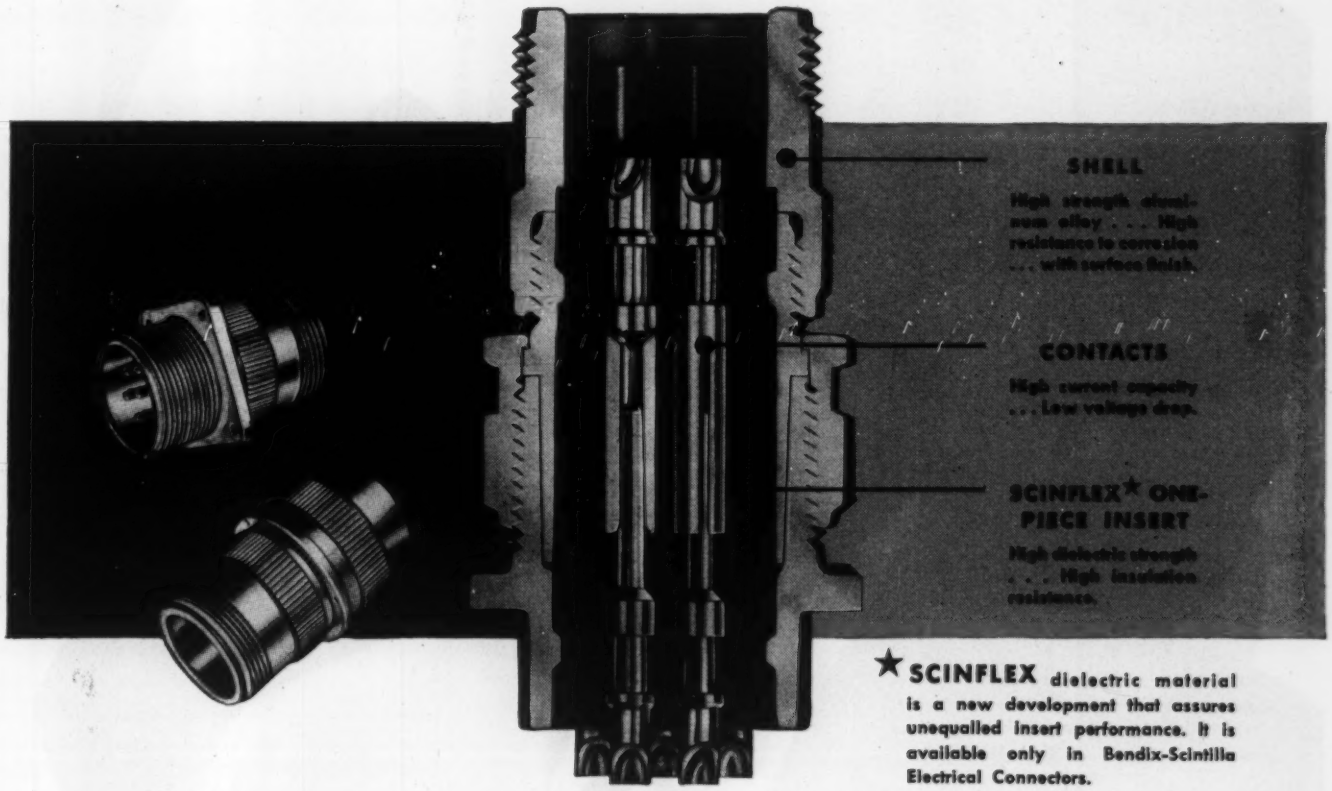
NICE

NICE BALL BEARING COMPANY
NICETOWN · PHILADELPHIA · PENNSYLVANIA

ONLY BENDIX-SCINTILLA

ELECTRICAL CONNECTORS

offer you SCINFLEX★ SUPERIORITY!



★**SCINFLEX** dielectric material is a new development that assures unequalled insert performance. It is available only in Bendix-Scintilla Electrical Connectors.

The use of **SCINFLEX** dielectric material, an exclusive Bendix-Scintilla development of outstanding stability, increases resistance to flash-over and creepage. And this is only part of the many new advantages you get with Bendix-Scintilla* Electrical Connectors. The contacts carry maximum currents with practically no voltage drop. In temperature extremes, from −67° F. to +300° F., performance is remarkable. Dielectric strength is never less than 300 volts per mil. Bendix-Scintilla Connectors have fewer parts than any other connector on the market—and that means lower maintenance costs and better performance. *TRADEMARK

PLUS ALL THESE OTHER FEATURES

- Moisture-proof, Pressure tight
- Radio Quiet
- Single-piece Inserts
- Vibration-proof
- Light Weight
- High Insulation Resistance
- Easy Assembly and Disassembly
- Fewer Parts than any other Connector
- No additional solder required

Write our Sales Department for detailed information.

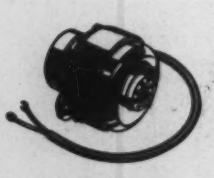
BENDIX
SCINTILLA

F.E. Myers assures

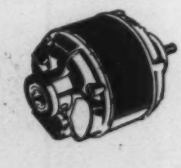
SAYS MR. C. GINN, Vice President and General Manager of the F. E. Myers & Bro. Co., one of the leading water pump manufacturers: "We regard the use of standard motors for pump and water system service as an important advantage to our customers. Motor exchange plans, made possible by the use of standard motors, enable the user to get his pump back in operation with a minimum of delay. Any interruption of water supply is serious and, if extended, may be disastrous, especially to farmers. The use of standard motors and consequent ease of replacement and service is a big talking point for our products."

More for your money with

STANDARD G-E Fractional-Horsepower MOTORS



Unit-Bearing Fan



Washing Machine

Oil Burner

Machine Tool

Gas Pump

Hermetic Refrigeration

customer satisfaction WITH GENERAL ELECTRIC STANDARDIZED Fractional Horsepower MOTORS

Here's the motor that F. E. Myers & Bro. Co. says helps make customer service a strong selling tool—the G-E General Purpose Capacitor-Start Motor. It is widely used on water-pumping systems, commercial refrigeration and air conditioning compressors, industrial air compressors, material handling equipment, motorized tools, commercial laundry equipment . . . wherever high starting torque, long life, and minimum servicing are required.

The General-Purpose (Type KC) has an open (dripproof) enclosure, 40 C rise, and a solid base. It is immediately available in ratings from 1/6 to 1 hp; 3450 to 1140 rpm; constant speed; single-phase, 60, 50, or 25 cycles. For more details, call or write your nearest G-E sales office. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

THEY'RE QUIET . . . AND COMPACT . . . AND RUGGED

Sleeve bearings are bored to a mirror-like finish for long-lived, quiet operation. Starting is snappy, yet quiet.

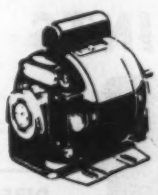
Sound design and the use of modern insulating materials has packed a lot of motor into a little space.

The sturdy end shields, rigidly support the bearings and the frame itself is all-steel, rolled and machined.

GENERAL ELECTRIC

700-96

Belted Fan

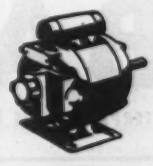


Coal Stoker

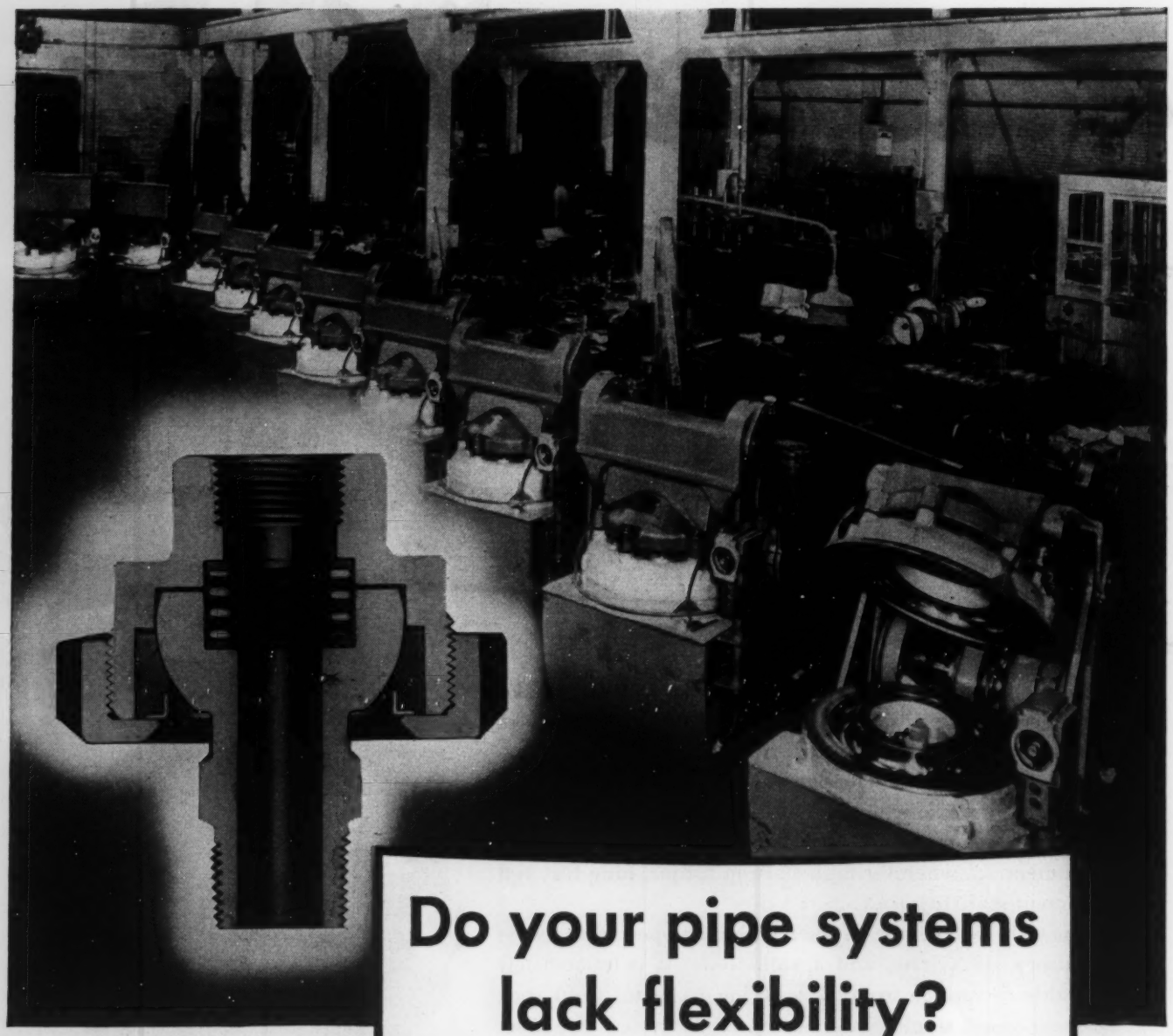
Jet Pump

Shaft-Mounted Fan

Sump Pump



General Purpose



Do your pipe systems lack flexibility?

Here's an example of how

BARCO CAN PROVIDE IT

Every tire press in this assembly line is equipped with Barco Swivel Joints which provide the piping flexibility required to open and close the press.

For over 30 years Barco Joints have been serving industry and transportation—each year becoming more and more popular. Today, they are used in almost every kind of job requiring *flexible* fluid-conveying systems. By absorbing strain and stress, by compensating for expansion and contraction, Barco Joints have long been practically indispensable. Write for full information to Barco Manufacturing Company, 1807 Winnemac Avenue, Chicago 40, Illinois. In Canada: The Holden Co., Ltd., Montreal, Canada.

BARCO FLEXIBLE JOINTS

FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

Not just a swivel joint ...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

"MOVE IN EVERY DIRECTION"

with WHITNEY Roller Chain Drives

Delivery constant, full power from driver to driver mechanisms . . . that's one of the major advantages of using chain drives.

Deeply seated in the sprocket, Whitney Roller Chain eliminates power loss because there is no slippage or friction loss. This means that full rated horsepower is delivered . . . constant speed maintained . . . highest transmission efficiency always obtained.

In addition, Whitney Chain absorbs shock loads without breakage, assuring long operating life; while the flexibility and adaptability of chain drives simplifies design problems.

For positive power transmission specify and use Whitney Roller Chain . . . the *all steel drive*. Write for information.

CHAIN DRIVE IS BETTER

- Positive Grip
- Transmission of full horsepower
- High resistance to shock loads
- High load carrying capacity
- Simplifying transmission designs
- Low Maintenance
- Ease of installation
- Long operating life
- Constant uniform speeds

WHITNEY

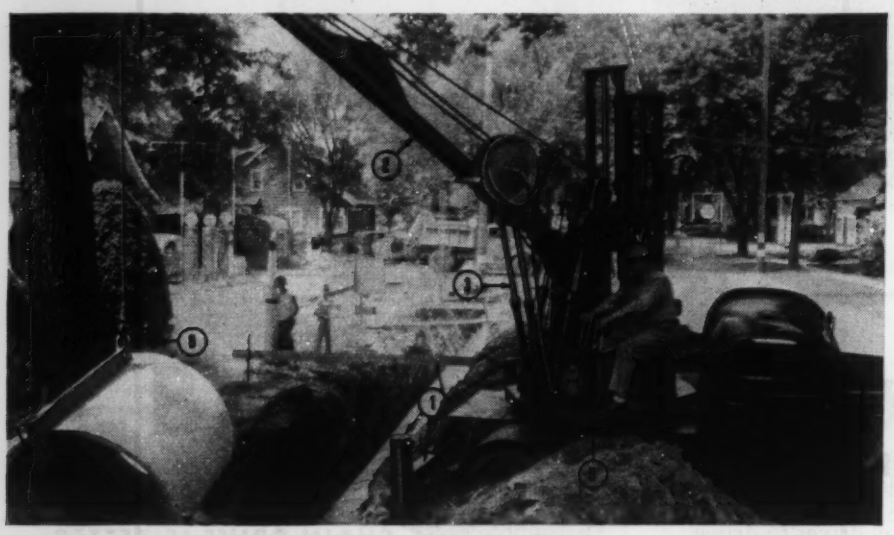
WHITNEY CHAIN & MFG. CO.
Division of
Whitney-Hanson Industries Inc.
205 Hamilton St.,
Hartford 2, Conn.

LOOK HOW BLACKHAWK *High-Pressure Hydraulics** SOLVED THESE MANUFACTURERS' PROBLEMS

**IMPORTANT: NEW, TENTATIVE INDUSTRY-WIDE HYDRAULIC STANDARDS HELP TO FOCUS ATTENTION ON BENEFITS FROM HIGHER PRESSURES —Blackhawk specializes in engineering and manufacturing hydraulic components and systems with pressure ranges from 1,000 p.s.i. up to 10,000 p.s.i. This range (according to "Hydraulic Standards for Industrial Equipment" compiled recently by the Joint Industry Conference) overlaps the "Medium High" pressure class (above 500 to and including 1,200 p.s.i.) and the "High" pressure class (1,200 to 3,000 p.s.i.) and the "Extra High" pressure class (above 3,000 p.s.i.). These new industry titles help Blackhawk customers identify the superior pressure ranges of their hydraulic systems.*

THESE HIGHER PRESSURES CREATE UNUSUAL BENEFITS for users of Blackhawk components. Blackhawk PUMPS and VALVES (because of higher pressures) are strikingly compact and RAMS have smaller diameters. The entire hydraulic system gains from (1) less weight, (2) easier installation, (3) less friction, (4) improved appearance, (5) simplicity, (6) lower costs and (7) easier service.

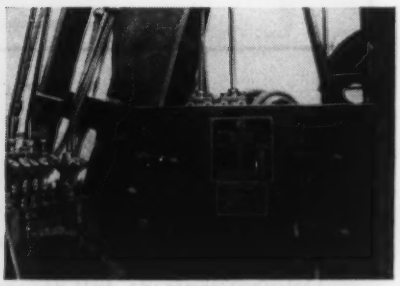
Over 5000 Parts Eliminated by Blackhawk Pumps and Valves



EVERY POUND IS "LIVE WEIGHT" because compact Blackhawk Hydraulics replace customary mechanical devices or large, low-pressure hydraulic systems. Blackhawk valves and pumps activate the following operations: (1) control outriggers to hold crane in position; (2) extend or contract boom; (3) lower or raise boom; (4) lower and lift hoist line; (5) rotate boom; (6) when clamshell is used, jaws are hydraulically controlled.

Unique Development in Crane-Excavator Field is All-Hydraulic

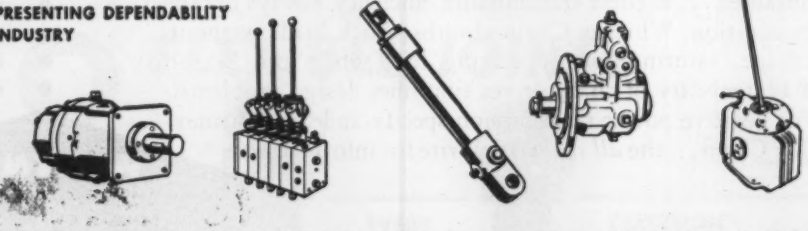
Blackhawk high-pressure hydraulic components, including multiple control valves and compact heavy-duty power-driven pumps, eliminate an estimated 5,000 parts (gears, shafts, clutches, drums, brakes, etc.).



THESE COMPACT BLACKHAWK "VALVBANKS", which can be safely managed by even an inexperienced operator, control functions of the all-hydraulic crane-excavator.

BLACKHAWK HYDRAULIC EQUIPPED

AN EMBLEM REPRESENTING DEPENDABILITY THROUGHOUT INDUSTRY



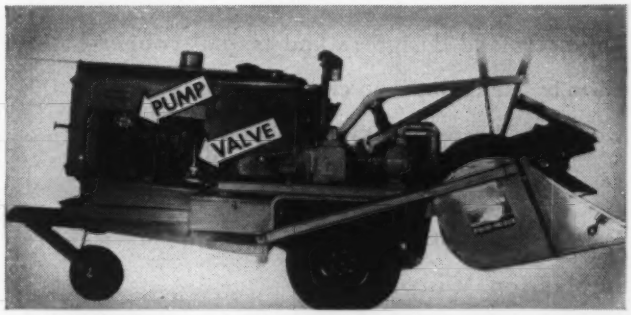
PIONEER SPECIALISTS IN HIGH-PRESSURE HYDRAULICS FOR 25 YEARS

Blackhawk Pumps, Rams and Valves Answer the Need for Simple, Economical Controls On This Pulverizer

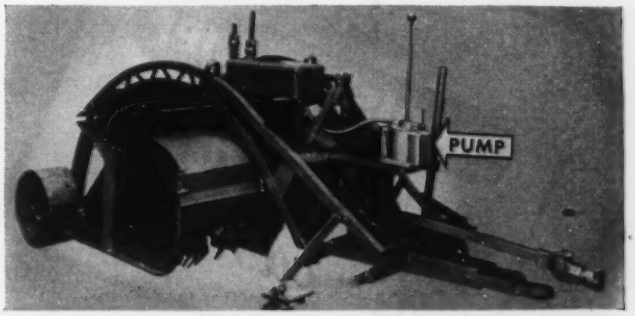
Manufacturer Benefits by Having One Dependable Source For Many Hydraulic Components

This manufacturer had the problem of finding economical, compact means to supply precision depth control for his pulverizer. Blackhawk's integrated hydraulic controls offered the ideal answer because they are compact, simple and low in cost. Subsequent adaptations of the pulverizer, as pictured below, utilized many other components from the long line of standard Blackhawk hydraulic devices.

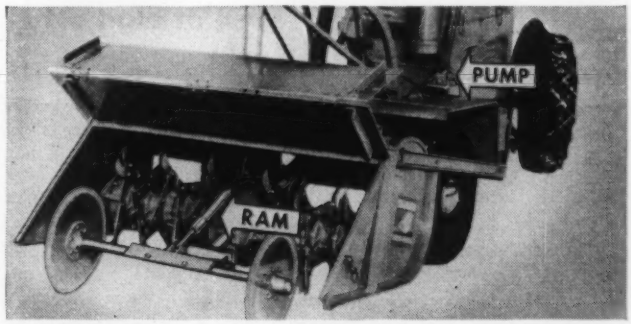
The great range of Blackhawk hydraulic devices enables the equipment manufacturer to depend on Blackhawk as its key source for hydraulics—creating savings in development, procurement and other functions.



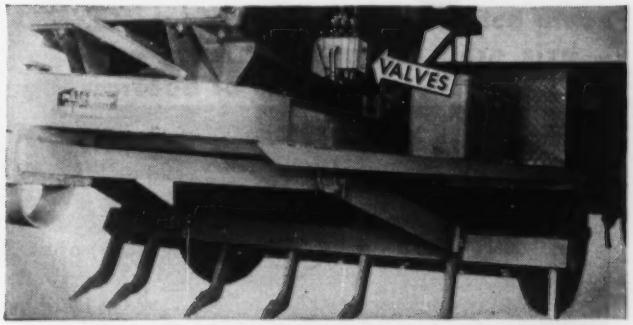
1 A BLACKHAWK POWER-DRIVEN PUMP AND CONTROL VALVE are on this Auxiliary Spray Bar and Pump which closely synchronize the addition of liquids to "mix."



2 A MASS-PRODUCED, STANDARD BLACKHAWK HAND PUMP, plus a ram, are incorporated on the pulverizer when adapted to airport-levelling operations.



3 A BLACKHAWK HYDRAULIC RAM forces tines into sheet ice when the pulverizer is converted to an ice rotor.



4 UNDER CONTROL of Blackhawk "Valvbanks" — the pulverizer's scarifier attachment utilizes these compact, multiple control valves.

Sensible costs, practical design are no accident at Blackhawk...
they are born from proven Engineering and Manufacturing policies

Only with Blackhawk can you draw from a quarter-century of experience in engineering and manufacturing of high-pressure hydraulic equipment! And you get more than the invaluable benefits of high-pressures . . . you also benefit from exclusive refinements built into Blackhawk components. Comparatively, Blackhawk's PISTON-TYPE pumps furnish greater volumetric efficiencies in the higher pressure ranges—and Blackhawk offers a host of other exclusives in ram and valve designs.

"Specials" or "Standards" . . . A great many manufacturers depend on Blackhawk for specially-designed hydraulics to fit individual needs. Blackhawk has the engineering service for this work. But Blackhawk also can furnish components that are of standard design, continuously produced and sold in quantities for installation on products of other manufacturers. These products and integrated services are catalogued in profusely illustrated literature. Ask for bulletins on "High-Pressure Hydraulics," then let us counsel in confidence.

Blackhawk Mfg. Co., 5300 W. Rogers St., Milwaukee 1, Wis.

BLACKHAWK®

COMPLETE HYDRAULIC SYSTEMS—PUMPS (HAND AND POWER-OPERATED), VALVES AND RAMS.

LESS LIMITED DESIGNING

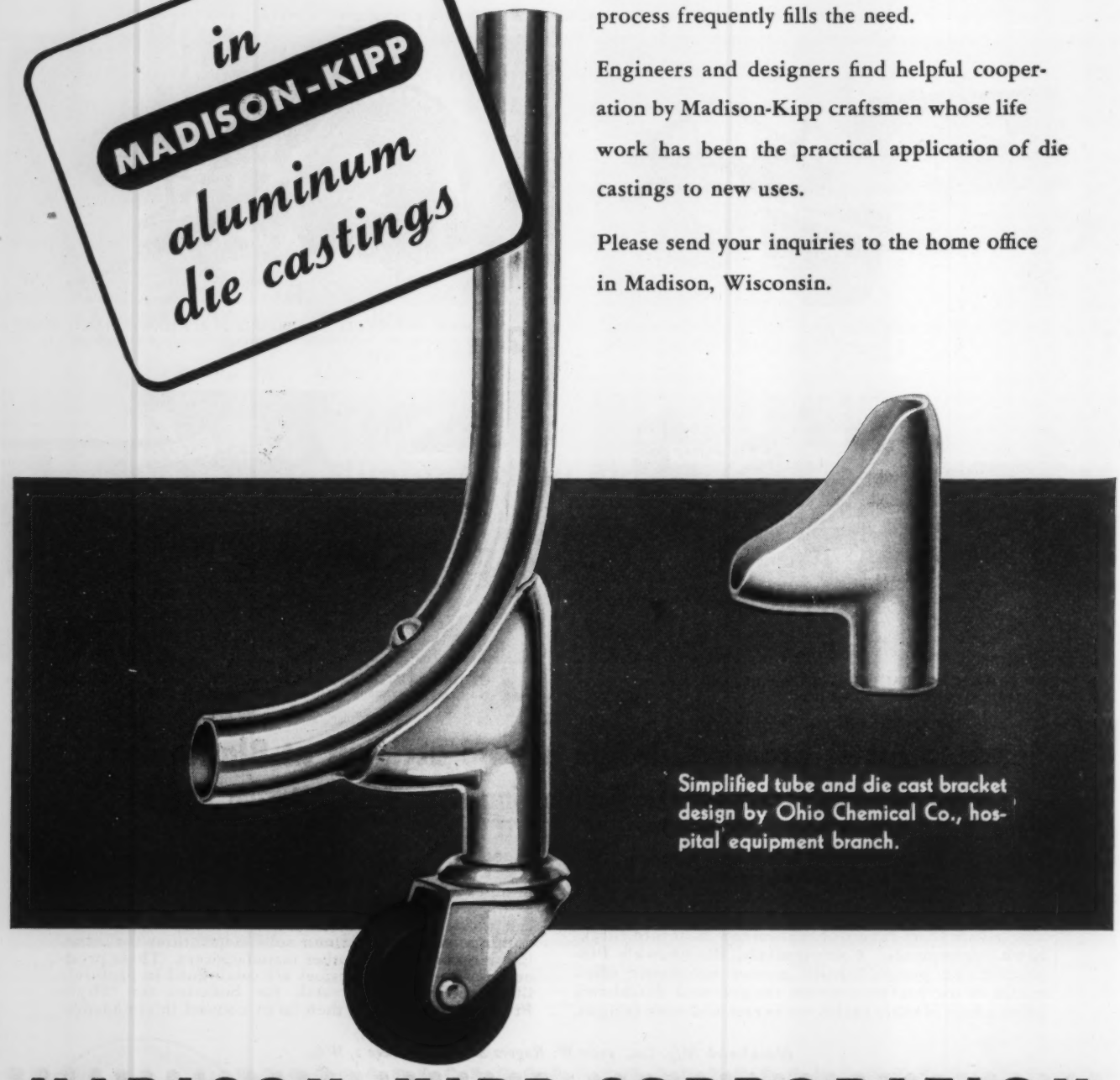
at No Cost Penalty - Often at Savings

in **MADISON-KIPP** *aluminum die castings*

Manufacturers are "design conscious" if — the cost is less or no greater for more value. And that is where the Madison-Kipp die casting process frequently fills the need.

Engineers and designers find helpful cooperation by Madison-Kipp craftsmen whose life work has been the practical application of die castings to new uses.

Please send your inquiries to the home office in Madison, Wisconsin.



Simplified tube and die cast bracket design by Ohio Chemical Co., hospital equipment branch.

MADISON-KIPP CORPORATION

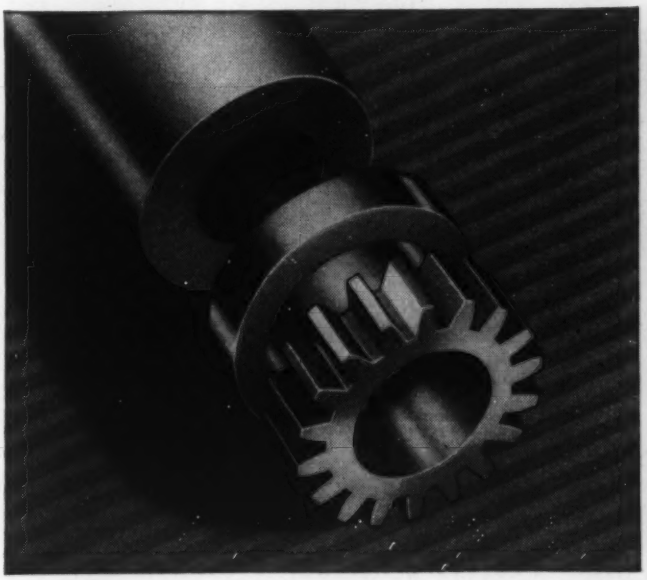
210 Waubesa Street, Madison 10, Wis., U.S.A.

ANCIENS ATELIERS GASQUY, 31 Rue du Marias, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.

WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand.

- *Skilled in* DIE CASTING *Mechanics*
- *Experienced in* LUBRICATION *Engineering*
- *Originators of Really High Speed* AIR TOOLS

Two ways TIMKEN® seamless tubing cuts costs on hollow parts



1. No hole to bore

The first step in production is already finished when you use Timken® seamless tubing instead of bar stock for making hollow or ring-shaped parts. There's no hole to bore, less waste stock to pay for. Elimination of drills on automatic machines often leaves space for other tools, sometimes speeding production as much as 200 per cent!

Timken seamless tubing offers you a range of sizes up to 10½" O. D., covering a wide variety of requirements. Rigid control throughout every step in manufacture results in steels of fine forged quality and refined grain structure, with uniform machinability and heat-treating. This means a better product for you, with fewer rejects and increased customer satisfaction.

2. TIMKEN® tube engineering service gives you the most economical tube size—guaranteed to clean up.

When you make use of Timken tube engineering service, you can be sure of minimum machining time—maximum saving of metal. That's because the Timken tube engineering service takes full responsibility for giving you the most economical tubing for your particular job—and guarantees that it will clean up to your dimensions. We take all the risk!

This guaranteed service is made possible by the outstanding uniformity of Timken tubing and by the largest assortment of roll sizes of any mechanical tubing mill in the country. Get details of this service now—without cost or obligation. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing

TRY this Low Cost Pump for:

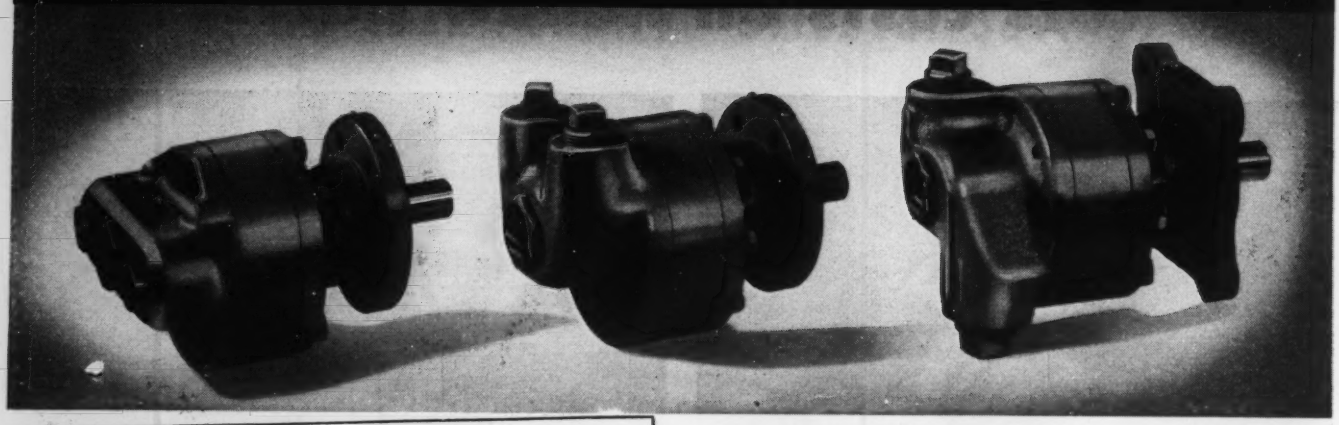


Illustration shows the Model 5W with porting arrangements that can be furnished. Two styles of flange mountings are shown and foot mounting bracket can be furnished (extra) if desired.

QUIET, EFFICIENT OPERATION

The Sundstrand Model 5W pump incorporates the outstanding Rota-Roll principle and pumping members which are responsible for the quiet, efficient operation in over 1,500,000 pumps. Because the basic elements are common to many other Sundstrand hydraulic units, the cost of the 5W pump is low.

Try it on the following:

Materials handling equipment, agricultural machinery, industrial heating units, lift trucks, and similar equipment can be improved through the application of the Model 5W.

Small and Compact (see illustration) will lend itself to and improve your product appearance.

High Overall Efficiency at maximum continuous duty pressure.

3 Standard Porting Arrangements. Another desirable feature of the Model 5W is its versatility in mounting and porting. The illustration above shows porting arrangements that can be furnished, making the pump adaptable to practically any piping requirements.

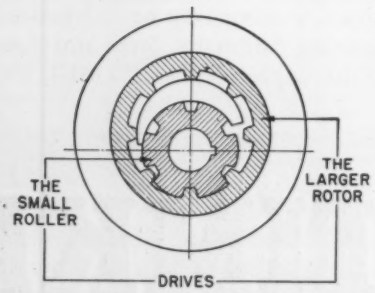
Available in 7 Sizes Ranging from 4 to 10 GPM. The Model 5W is furnished in 7 different capacities ranging from 4 to 10 GPM at 1200 RPM. Capacities are determined by width of pumping members, and all 7 sizes of pumps with the same combination of porting and mounting arrangement have the same basic dimensions excepting overall length. The pump is suitable for 1200 PSI service and operation at speeds up to 1800 RPM.

Low Cost because the basic elements of this efficient constant volume pump are common to many other Sundstrand hydraulic units. Sheave or pulley type drive pump can also be furnished.

THESE FEATURES INSURE ITS QUIET, EFFICIENT PERFORMANCE

Rota Roll Principle

of pumping members promotes quiet operation, longer life because smaller roller is keyed to shaft and drives outer member at a speed 25% lower than motor speed.



Smooth, Uniform Flow at all Pressures

because rotating roller and rotor are self-emptying, eliminating turbulence and other interference with smooth, uniform flow of oil.

FREE Additional Data

will be furnished on request. Write today, ask for M-40.

SUNDSTRAND MACHINE TOOL CO. ROCKFORD, ILLINOIS, U.S.A.

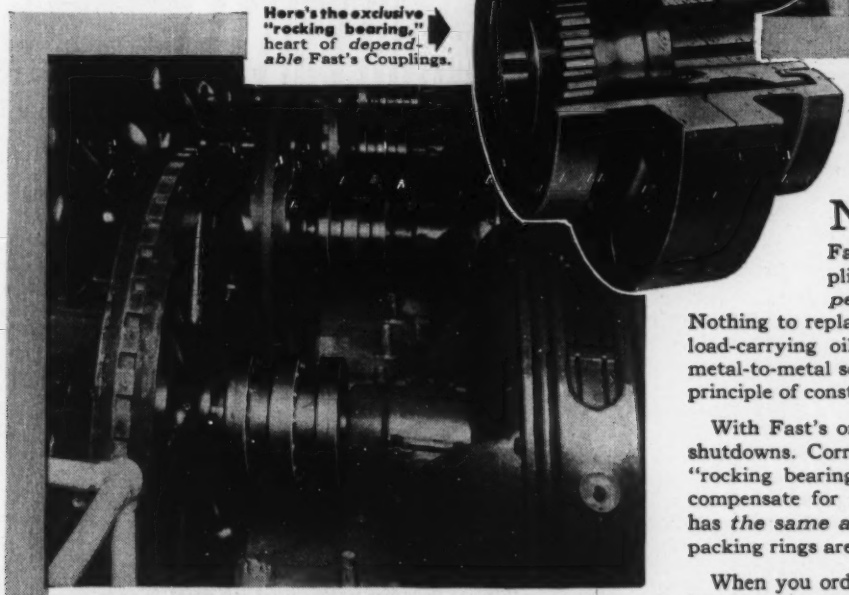
SUNDSTRAND HYDRAULIC DIVISION

2559 ELEVENTH STREET • ROCKFORD, ILLINOIS

FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS

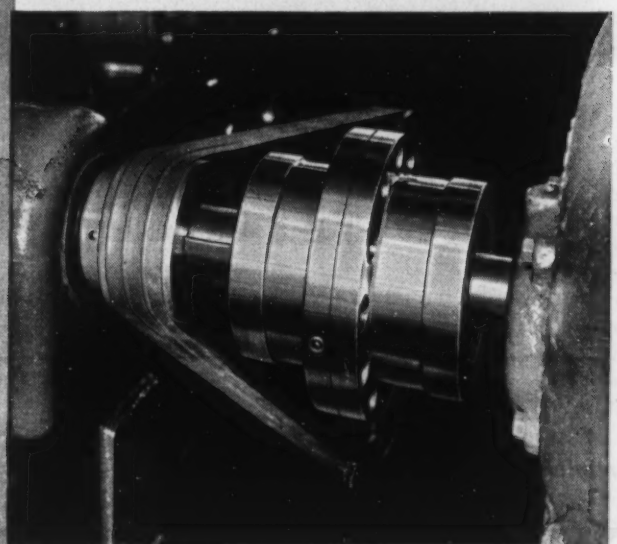
Here's Freedom from *Coupling Shutdowns* for ALL INDUSTRIES

IN OIL FIELDS Fast's are in service to compensate for shaft misalignment, in all kinds of weather, subject to moisture, dirt and grit . . . yet they transmit power without costly coupling shutdowns!



Here's the exclusive "rocking bearing," heart of *dependable* Fast's Couplings.

CHEMICAL PROCESSING plants use Fast's Couplings because *exclusive* metal-to-metal seal keeps out impurities—eliminates lost time due to coupling failure! These Couplings have been in service since 1922!



MANUFACTURING processes of all kinds throughout industry demand *dependable* Fast's Couplings that *do not break down* under severe conditions!

NO matter what you make—no matter how much horsepower you use in a year—Fast's Couplings virtually eliminate all coupling failure in your plant! There are *no perishable parts* to wear or fail in Fast's! Nothing to replace . . . they're easy to maintain. Even the load-carrying oil is *completely guarded* by a positive metal-to-metal seal formed by exclusive "rocking bearing" principle of construction.

With Fast's on your job you can forget about coupling shutdowns. Correctly engineered position of oil-protecting "rocking bearing" allows for *freedom of movement* to compensate for misalignment because its *spherical base* has *the same axis* as the hub spline faces. No perishable packing rings are used at this critical spot . . . or elsewhere!

When you order Fast's you get years of top engineering experience, Koppers' high standards of workmanship and unexcelled service, including available parts if required by change of drive, *even if your Fast's have been running for 30 years!* For full information mail the coupon below. Address Koppers Co., Inc., Fast's Coupling Dept., 254 Scott Street, Baltimore 3, Md.

KOPPERS

FAST'S *Self-Aligning* COUPLINGS

SEND FOR FREE CATALOG!

KOPPERS CO., INC., FAST'S COUPLING DEPT.,
254 Scott Street, Baltimore 3, Md.

Please send me the free catalog that gives complete detailed information about Fast's Couplings.

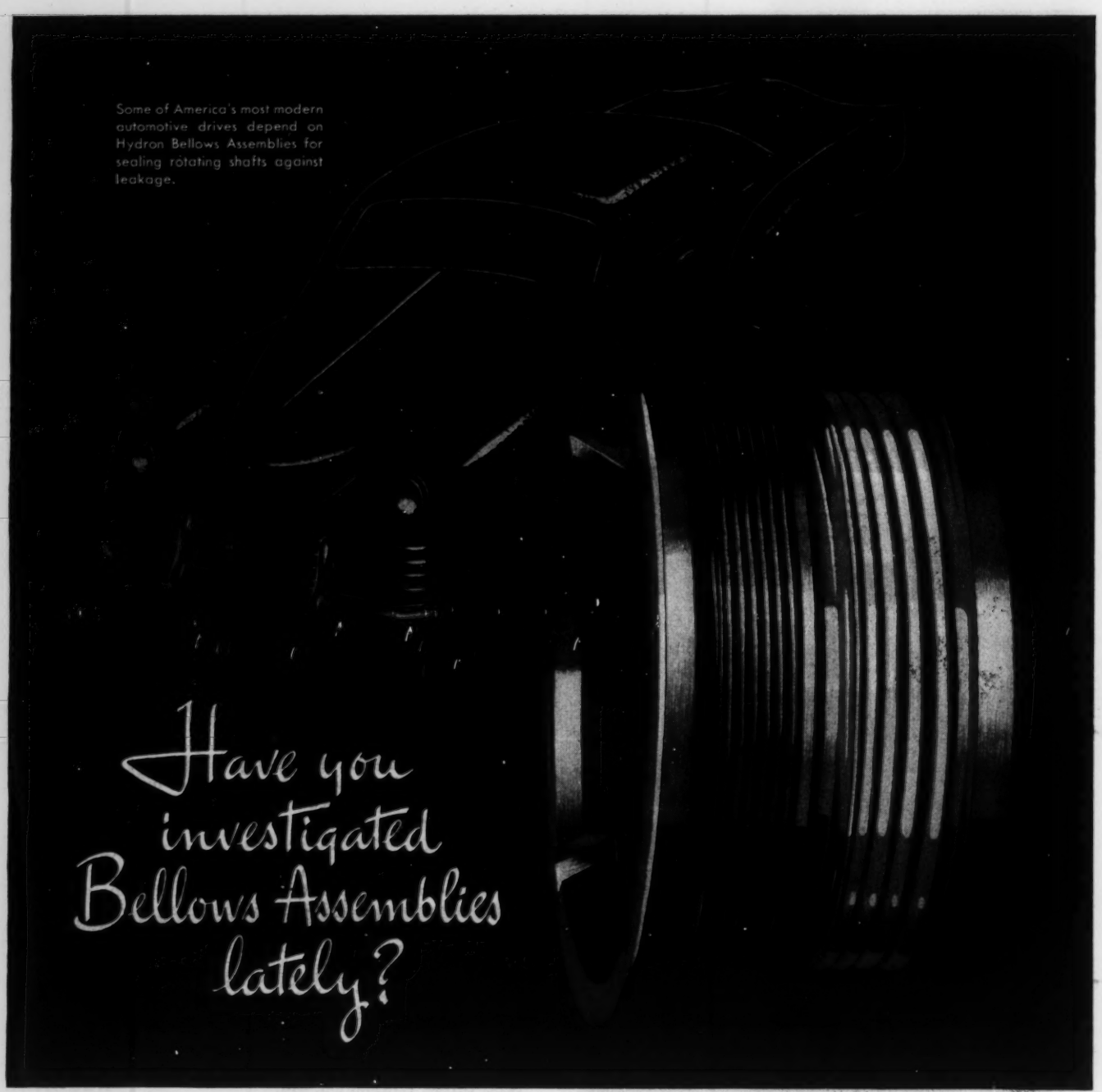
NAME.....TITLE.....

COMPANY.....

ADDRESS.....

CITY.....ZONE.....STATE.....

mail today



More and more leading firms are improving the quality of their products by using bellows assemblies to seal shafts or valves against leakage, to control temperature and pressure and to transmit motion. Maybe you, too, should consider bellows assemblies before your designs are too far advanced. Our engineering department will gladly study your sketches and specifications in strict confidence and make a recommendation. This free service does not obligate you in any way. Write: CLIFFORD MANUFACTURING COMPANY, 566 GROVE STREET, WALTHAM 54, MASS. *Division of Standard-Thomson Corporation.* Offices in New York, Detroit, Chicago, Los Angeles.

CLIFFORD

HYDRAULICALLY-FORMED BELLOWS AND BELLOWS ASSEMBLIES

ALL-ALUMINUM OIL COOLERS FOR AIRCRAFT ENGINES

First with the Facts on Hydraulically-Formed Bellows

Further Information?

IF YOU DESIRE MORE INFORMATION ON ANY ADVERTISEMENT IN THIS ISSUE

Here's What You Do:

Write the name of the advertiser and the page number of the ad in the spaces provided on the card. Check the type of information you want—whether it has to do with price, where you can buy it, or more needed details—or all three, if you wish. After you have finished going through MACHINE DESIGN and have jotted down all the ads on which you'd like more information, just tear off the card and drop it in the mail. No postage is required. We'll have our staff forward this information immediately to the advertiser, so that you will be relieved of the necessity of writing a number of letters. You will then hear directly from the advertiser, answering your request. Because we know that MACHINE DESIGN gets around, and that more than one person sees your copy, we have made up three cards so that if you are one of the later readers, you can still have the opportunity of taking advantage of this service.

Please send further information on the following advertisements in this issue:

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COMPANY _____

ADDRESS _____

CITY _____ STATE _____

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Cleveland 13, Ohio

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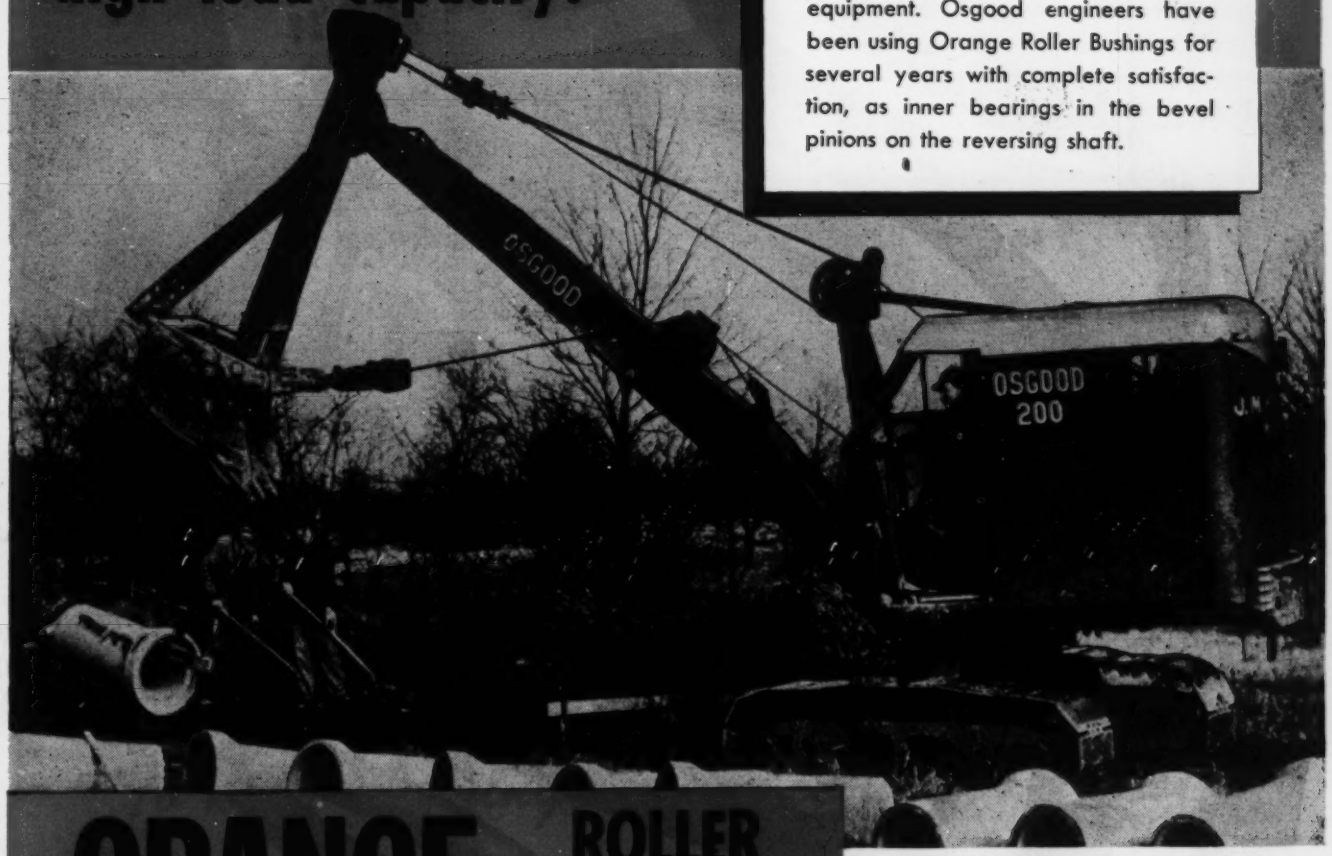
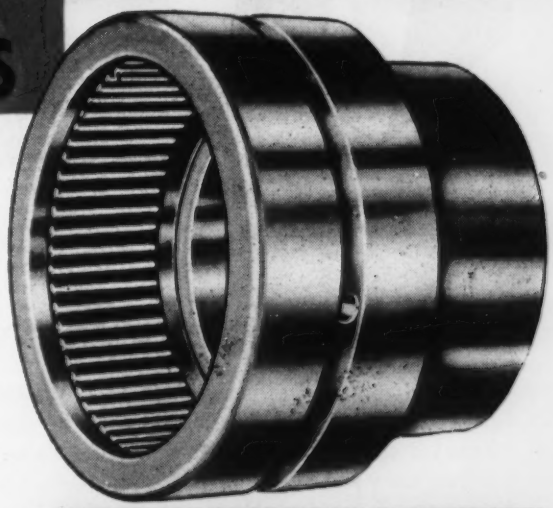
Compactly designed for high load-capacity!

The OSGOOD "200" packs a lot of stamina in a compact, sturdy, versatile machine. It is used with ½ yd. shovel, or with dragline, clamshell, hoe or crane equipment. Osgood engineers have been using Orange Roller Bushings for several years with complete satisfaction, as inner bearings in the bevel pinions on the reversing shaft.



ORANGE ROLLER BUSHINGS



ORANGE ROLLER BUSHINGS are built ruggedly to stand up in heavy equipment, yet have the fine precision and even-running to satisfy the most exacting machine tool requirements . . . all within minimum space allotments.

Small wonder that design engineers are using Orange Roller Bearings on rotating and oscillating parts, large and small, under heavy loads or high speeds, in every kind of equipment from precision honing machines to giant oilfield drilling rigs. An outstanding feature is the closer internal running clearances which minimize possibility of mis-alignment while running. Highly finished raceways further reduce friction and wear.

Orange Roller Bushings are available from stock in a full range of sizes. Consult our engineers on any application.

ORANGE ROLLER BEARING CO., INC.
556 Main Street, Orange, N. J.

Mail Coupon for engineering data

Orange Roller Bearing Co., Inc., MD
Orange, N. J.

Please send me your Roller Bushing Data Book

Name ..... Title .....

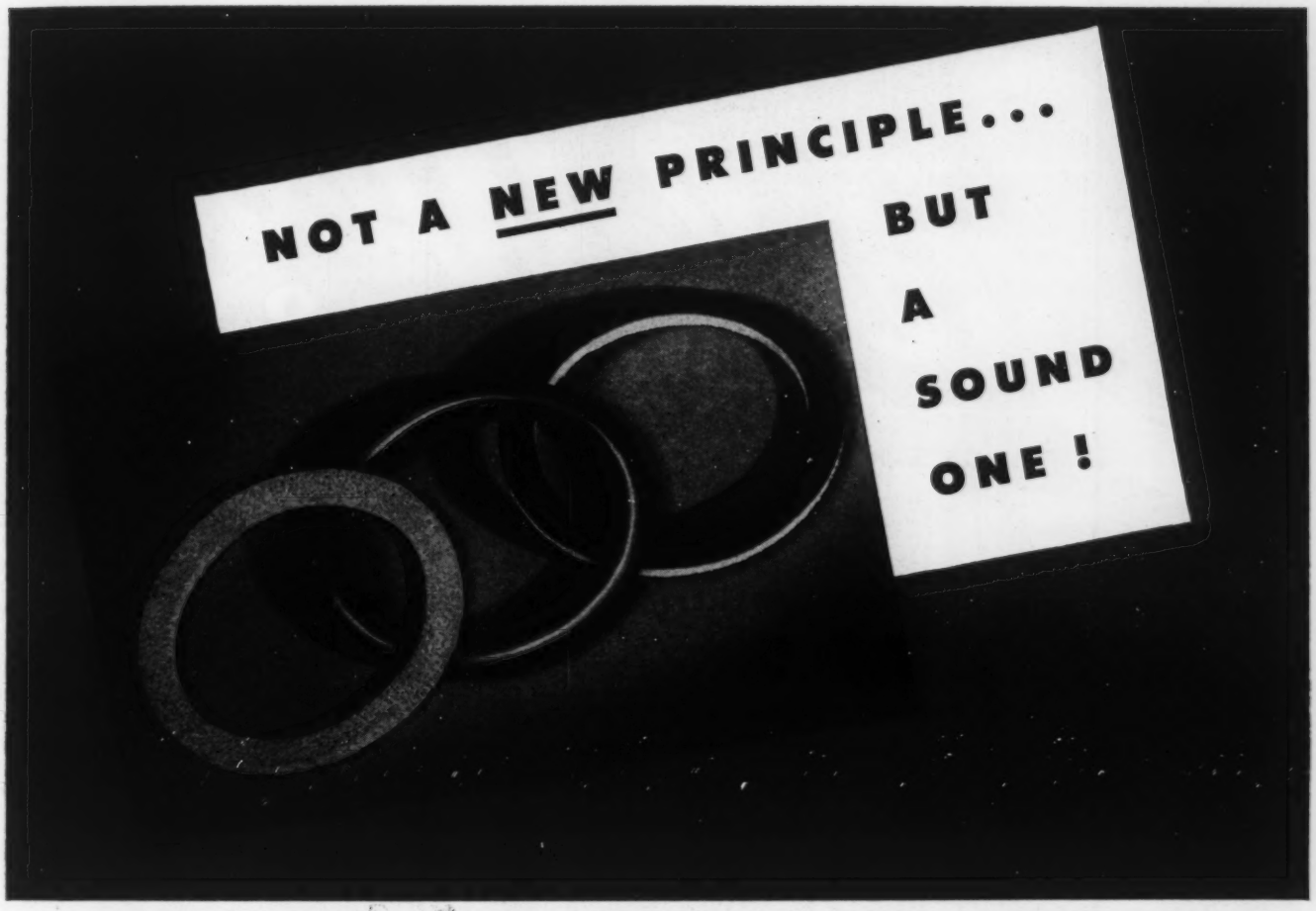
Company .....

Address .....

City ..... State .....

Wallace Barnes Springs

Bristol Connecticut



To keep "O" rings in place under pressure, use VIM *leather back-up washers*

For many years packing sets have included top and bottom support rings of the same or different material as the packings themselves.

This principle applies to "O" rings, which tend to extrude under high pressure. Our recommendation is to use VIM Leather Back-up Washers wherever pressures exceed 1500 PSI. Actually they are often used on lower pressures to prolong "O" ring life.

The leather washers absorb the oil medium, protecting and lubricating the ring. They keep the ring from extruding into the clearance. And they're relatively inexpensive.

You can buy both from Houghton

We supply *both* "O" rings and leather back-up washers in our complete line of hydraulic and pneumatic packings. Ask for Drawings S-7 and S-17 covering specifications. Or put your entire packing problem up to Houghton Engineers; many designers do. Write E. F. Houghton & Co., Philadelphia 33 and all principal cities.

HOUGHTON'S
VIM LEATHER and VIX-SYN PACKINGS

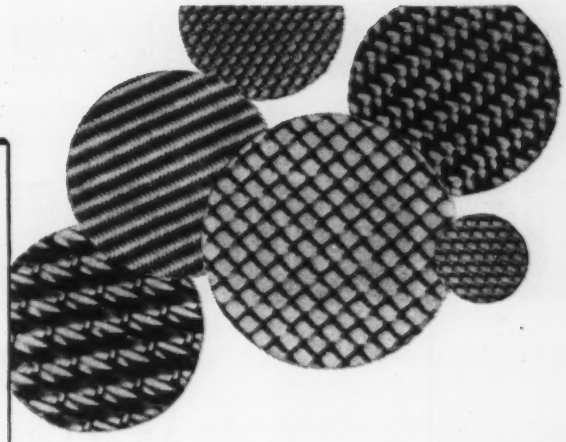
Here you see machining operations on Steel-Weld Fabricated heavy machinery parts. The Mahon organization offers you an unusual source for welded steel in any form regardless of design, size, or weight . . . a source with complete facilities for producing, magnetic inspection, stress analysis, normalizing, grit blasting, machining, and spray painting. These facilities, backed by a staff of design engineering experts and highly skilled craftsmen, are your assurance of a better, smoother appearing job, embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
DETROIT 11, MICHIGAN

Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products

MAHON

Compare this Screen and Filter Cloth with any you are now using!



HOW durable are filters, strainers and screens in the equipment you design?

They won't be sources of trouble if you use wire cloth made of Monel*, Nickel or Inconel*.

These metals are rustless...corrosion-resisting... strong...tough. They endure extremes of temperature. They stand abrasive wear.

All standard weaves and meshes are available, as well as special construction for "special" jobs. You can specify just the type you need to build long life into your products.

This cloth can be fabricated into any practical shape or size element. Seams are readily joined by brazing, soldering or welding; retain full corrosion resistance.

The price? It's a surprise. Due to excellent working qualities, weavers can produce wire cloth of Monel, Nickel or Inconel at prices comparable to what you are now paying for cloth of less durable metal. *Fine weaves of Monel often cost less!*

Consult any quality weaver. *He'll be glad to quote on the wire cloth you need. For booklet,* **"ESTABLISHED WEAVERS,"** *write to our Frank Bailey.*

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

*Reg. U. S. Pat. Off.

Monel* Nickel Inconel*

"Task Metals" for Industry

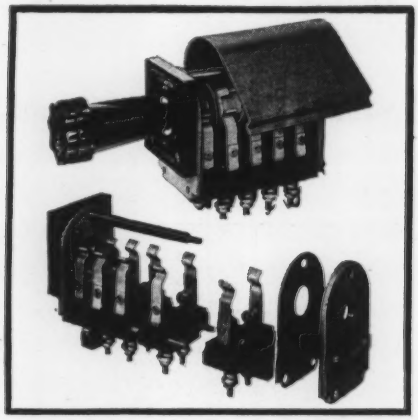
EMBLEM OF SERVICE
INCO

ALLIS-CHALMERS OFFERS EQUIPMENT

Facts about A-C ALLIS-CHALMERS control

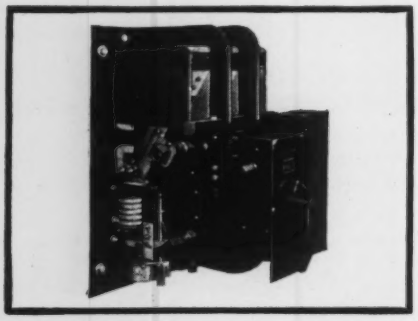
Pictured here is *part* of Allis-Chalmers wide line of switchgear and control devices... being advertised for the first time to designers! Now, you can get high quality control devices from the *same* O.E.M. supplier who offers the widest range of V-belt equipment—Texrope—as well as a-c and d-c motors from ½ hp up. For a choice of over 1600 *industry accepted products,* make your headquarters Allis-Chalmers!

Texrope is an Allis-Chalmers trademark



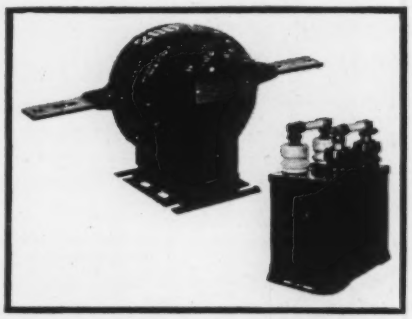
ROTARY CONTROL SWITCHES

Here's a new type rotary control switch especially designed for rough repetitive service. Solid, positive contact motion is achieved through use of square shaft and star-holed contact segments. For ammeter, voltmeter, frequency meter, P. F. meter, circuit breaker, and many other uses. Continuous rating 10 amps, at 600 Volts.



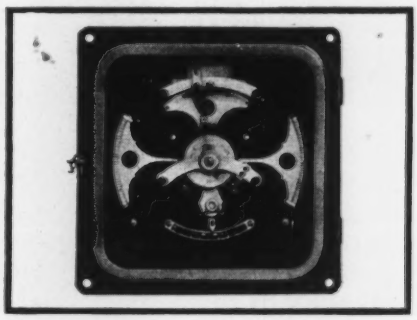
AIR CIRCUIT BREAKERS

Manually or electrically operated for service up to 600 volts a-c. Inverse time series overcurrent trip permits adjustment of overload setting from 100% to 200% of breaker ampere rating, and adjustment of time delay. Also open and enclosed types for individual wall mounting. Type G-25 rated 25,000 RMS amp interrupting capacity; 50 to 600 amp; 600 volts a-c. Type G-50 rated 50,000 RMS amp interrupting capacity; 200 to 1600 amp; 600 volts a-c.



CURRENT AND POTENTIAL TRANSFORMERS

Circular shaped current transformer coils prevent distortion under heavy overcurrents. Flat conductors, accurately formed are hand wrapped with the finest grades of insulating tapes. Construction of potential transformers is compact and strong. Coils are thoroughly impregnated under a vacuum pressure process, insuring a solid coil which is impervious to moisture.



GENERATOR VOLTAGE REGULATORS

For dependable, smooth, sensitive voltage regulation, you can depend on Allis-Chalmers rocking contact regulators. The principle of *rocking* the field resistance contacts produces smooth, almost frictionless resistance changes. Because of only slight mechanical movement, response is quick with very little bearing wear. Eight type sizes are available for control of a-c and d-c generators of all ratings.

Pioneers in Power and Electrical Equipment From Generation Through Utilization

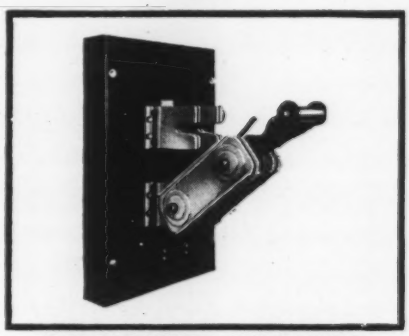
ALLIS-

AID TO ELECTRICAL DESIGNERS

and switchgear devices

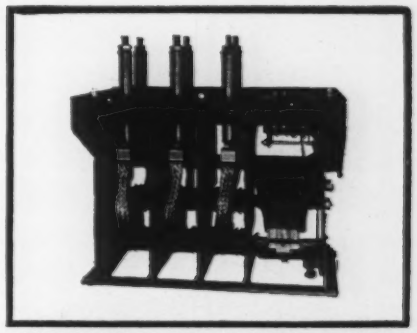
OIL CIRCUIT BREAKERS

Designed for control and protection of generators, feeder circuits, and transformer banks. Available in fully automatic, or non-automatic; manually or electrically operated. Ratings from 15,000 to 50,000 kva interrupting capacity; up to 7500 volts and 1200 amps. Also available are special oil circuit breakers for use in auto transformer circuits of large motor starters; manually operated.



DISCONNECT SWITCHES

Hook stick operated switches rated up to 2000 amp for either panel or framework mounting. Five thousand to 15,000 volts; 600, 1200, and 2000 amps. Also heavy duty clamp type switches for higher load concentrations. Available in panel mounting or unmounted, manual or hook stick operated. Up to 600 volts a-c; 3000 to 6000 amp; 750 volts d-c; 2000 to 10000 amp.



OIL IMMERSED CONTACTORS

Designed for heavy duty motor starting in industrial plants. Contact pitting is reduced by means of improved contact mechanism in which moving contact wipes and rolls with each operation. For use on full and reduced voltage squirrel cage and synchronous motor starters. Maximum ratings 200 amp; 1500 hp at 2300 volts. Interrupting ratings — 10 times full load motor current.

PUSH BUTTON STATIONS

Functional design plus pleasing appearance make these push button stations ideal for almost any industrial use. Available in light duty surface mounting, and heavy duty flush or surface mounting in hundreds of combinations. Ratings up to 600 volts a-c maximum.

All start buttons are encased in shrouds to prevent accidental starting, and locking bars are available so that buttons can be locked in the "stop" position. Delivery from stock.

SEND TODAY

for new 16 page bulletin 25B7095 covering Allis-Chalmers switchgear and control devices. It's filled with useful engineering information, including ratings and capacities. Illustrates over 75 control items.

A-C ALLIS-CHALMERS

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- Push Button Stations—Catalog Section 6128 ☐
- Generator Voltage Regulators—Catalog Section 2485 plus Bulletins B6143, B6015A, 146035, B6137 ☐
- Current Transformers—Catalog Sections 2801 to 2817 ☐
- Potential Transformers—Catalog Sections 2820 to 2828 ☐
- Disconnect Switches—Catalog Section 2591 ☐
- Oil Immersed Contactors—Catalog Section 6144 ☐
- D-C Relays and Contactors—Catalog Sections 6164 and 6142 ☐
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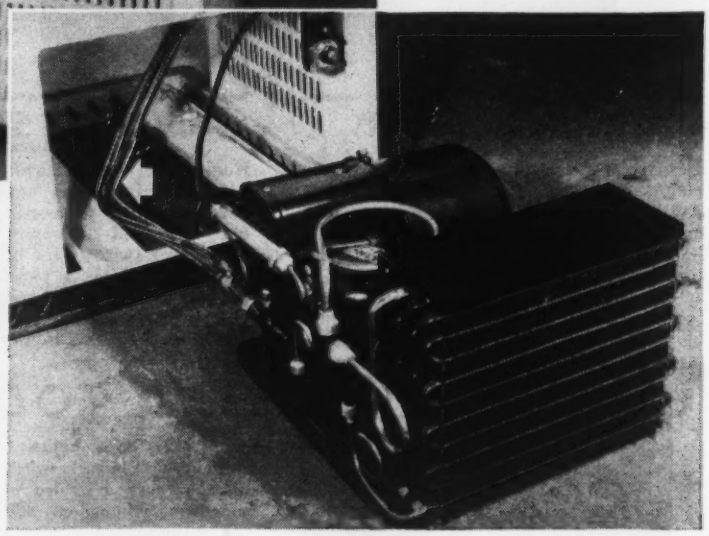

Here's the Penguin 40 gallon ice cream dispenser, made by Penguin Freezer Cabinet Corp., New York City. Inset shows condenser unit removed for service, yet refrigerant lines are (see arrow) completely connected, thanks to American Seamless.

AMERICAN SEAMLESS FLEXIBLE METAL TUBING gives Freezer Cabinets "pull-out" service feature

INSTANT ACCESSIBILITY is an important feature of Penguin Freezer Cabinets for farm, home and commercial use.

By using highly flexible American Seamless for refrigerant lines, the entire refrigerating unit slides out on a track for inspection or service without disconnecting.

Furnished complete with standard couplings, these reliable connectors are made from seamless bronze tubing, corrugated for flexibility, and covered with wire braid for added strength and prevention of elongation under pressure. This tubing is 100% tight, one-piece construction, rust and corrosion-resistant.

Have you a problem in conveying steam, oil, water, other liquids, semi-solids or gases . . . in eliminating vibration, overcoming misalignment, connecting moving parts or getting piping into cramped spaces? Experienced American engineers are at your service, ready to recommend the best American Flexible Metal Assembly to fit your particular needs.

Write for literature and feel free to consult our Engineering Department at any time. 49289

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American Metal Hose Branch

General Offices: Waterbury 88, Connecticut

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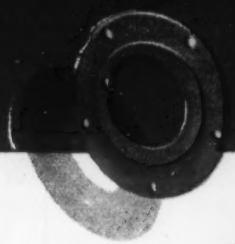
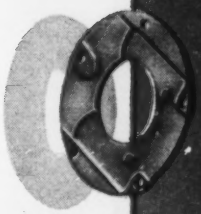
THE CANADIAN FAIRBANKS-MORSE COMPANY, LIMITED

here's how Microcastings solved a critical camera problem





BELL & HOWELL, leading manufacturers of motion picture equipment, found the answer to a critical and costly lens plate problem in MICROCASTINGS.

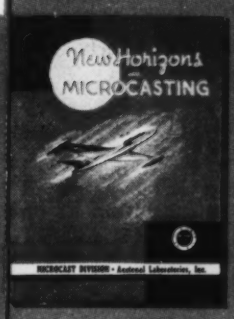
The intricate, stainless steel lens plate, too complicated for economical die casting or machining, was formerly coined of brass. However, coining dies did not stand up; and the cost of die maintenance was prohibitive.

Today the MICROCAST process has eliminated extensive and expensive die costs as well as machining cost . . . *another example of how* MICROCAST *is serving American industry, solving difficult problems on small castings.*

The Bell & Howell lens plate for the Sportster Camera shown above is an example of the intricate design problems involving thin wall sections, close location of holes, and exact tolerances which can be economically solved by the MICROCAST process.

PARTS NEVER before thought practicable for castings are being MICROCAST and are proving superior for service in consumer as well as commercial products.

Perhaps you have a parts problem involving factors of intricate design, high melting point alloys, or high machining costs. Austenal engineers are at your service and will be pleased to work with you on any of these problems.



NEW CATALOG AVAILABLE

A copy of the new 16 page book, "New Horizons with Microcasting," is yours upon request. It is the most complete report ever published on the subject of the MICROCAST process originated by Austenal Laboratories, Inc. See our catalog in Sweet's File for Product Designers.

MICROCAST PRECISION CASTINGS PROCESS

The name MICROCAST is a registered trademark of the Austenal Laboratories, Inc.

MICROCAST

MICROCAST DIVISION
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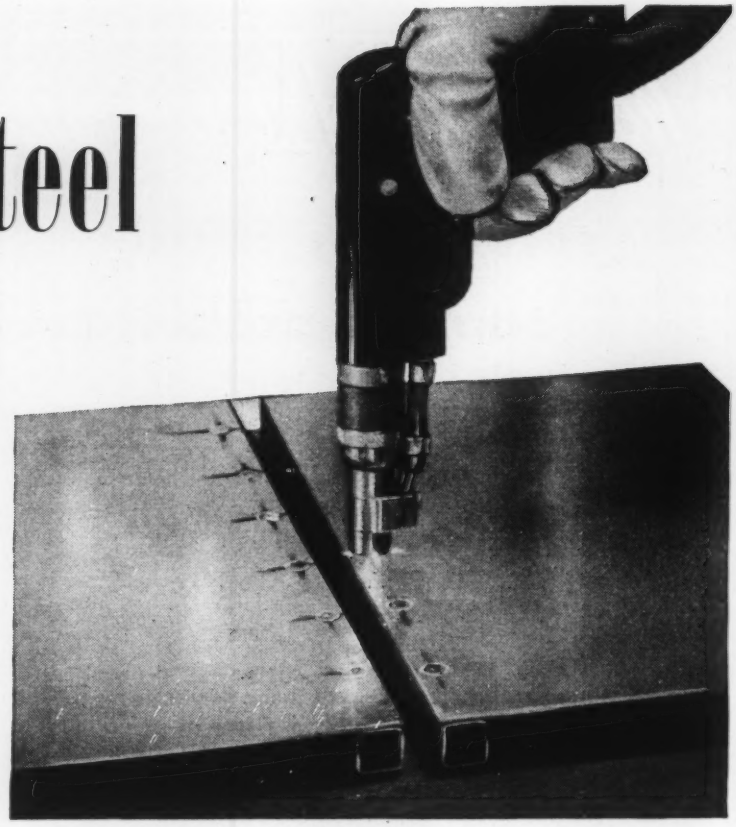
Join Sheet Steel

WITH THE "HELIARC" Trade-Mark SPOT WELDING TORCH



Welds Stainless and Carbon Steels . . . Needs no forging pressure, works from one side only . . . Easy one-hand operation, just press the trigger

This new application of inert gas-shielded arc welding meets a long-felt need in the assembly of light gage metals because welding can be done from one side and no forging pressure is required. With the HELIARC HW-8 pistol-grip torch you can spot weld ducts, tubes, containers, brackets, handles or almost any structure. Sheets of mild steel, low alloy, or stainless steel, .030 to .064 in. thick can be joined in one to two seconds per weld. Also, thin sheets can be spot welded to underlying material of any thickness. Thus, corrosion resistant sheets can be joined to mild steel plate.

It's no trick to weld with the HELIARC HW-8 Spot Welding Torch. Just press the "muzzle" of the "gun" against the work and pull the trigger. An automatic timer controls the entire operation. A single hose assembly, standard length 25-ft., connects the torch to the operating equipment. A convenient push-button release on the torch barrel gives easy adjustment of the electrode. These features make the HELIARC HW-8 Spot Welding Torch an ideal production line tool, easy and natural to use and as light and portable as an oxy-acetylene blowpipe.

See this torch in operation at our booth in the Western Metal Exposition—April 11 to 15, Los Angeles, Calif. or call any LINDE office for additional information on this new spot welding process.

Linde Trade-Mark

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

General Office: New York 17, N. Y. UCC Offices in Principal Cities

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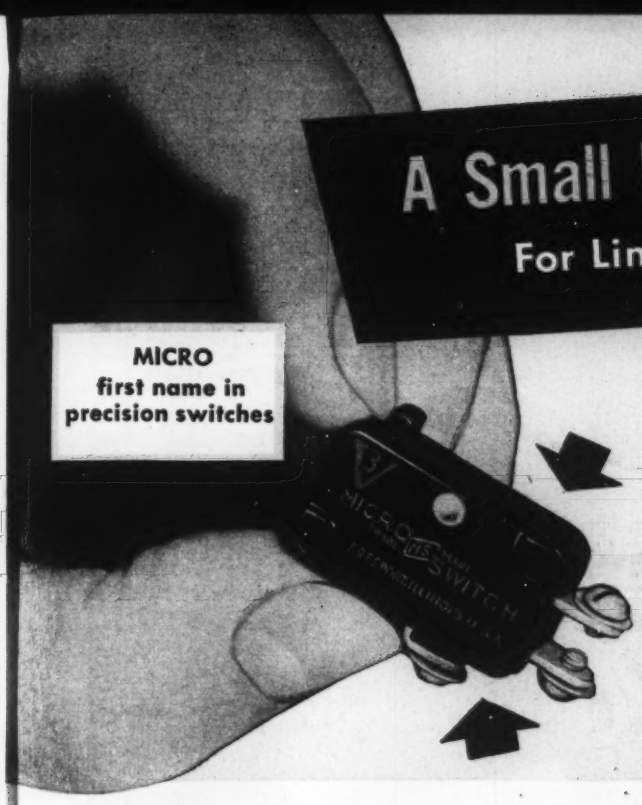
A Small MICRO High Capacity Switch

For Limit, Safety or Control Applications

MICRO
first name in precision switches



MICRO V3-1 SWITCH

This MICRO V3-1 Switch provides a MICRO quality snap-action precision switch of high electrical capacity to meet the demands of designs where economy of space is an important factor.

The rating of 10 amperes, 125 or 250 volts a-c, gives the capacity required of a limit switch, control switch or safety switch in many industrial applications. The D-C rating of 10 amperes, 28.5 volts (at sea level) meets the requirements of aircraft, automotive, marine, railway and other service where circuit potentials are less than 30 volts.

This MICRO V3-1 Switch is but one of 3900 variations of long-life precision switches developed by MICRO SWITCH to meet the needs of industrial designers. Call or write a MICRO SWITCH engineer at one of the offices listed below.

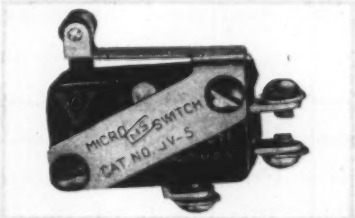
MICRO AUXILIARY ACTUATORS

Facilitate Operation of MICRO V3-1 Switches by Cams, Slides, and Other Mechanical Means

MICRO JV-1 ACTUATOR

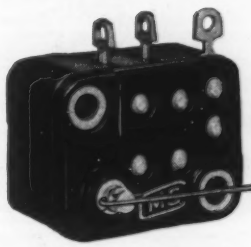
This is a leaf-type actuator for use where cam actuation is not severe or where cam and slide actuation are infrequent.

MICRO JV-5 ACTUATOR



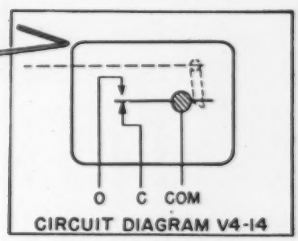
This is a roller-type actuator for use with rapid cam or slide actuation.

MICRO V4-14 LOW TORQUE SWITCH



Length: 1-1/16"
Height: 13/16"
Width: 9/16"

For use in instruments and other delicate equipment.



CIRCUIT DIAGRAM V4-14

This MICRO V4-14 low torque switch has double-throw contact arrangement and is Underwriters' Laboratories listed for 5 amperes, 125 or 250 volts a-c.

This switch permits positive operation on slow release actuation. Operating torque is 4 gram inches; release torque: .35 gram inches.

Circuit arrangement shown is single-pole double-throw design (V4-14). Also available: single-pole normally-open (V4-12).

"USES UNLIMITED"

A dramatic MICRO SWITCH 16 mm. sound motion picture in color, is available to industrial groups, training classes, schools and colleges. Running time, 35 minutes.

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MICRO MS SWITCH

A DIVISION OF FIRST INDUSTRIAL CORPORATION

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SOLUTION TO A DESIGN PROBLEM

stability

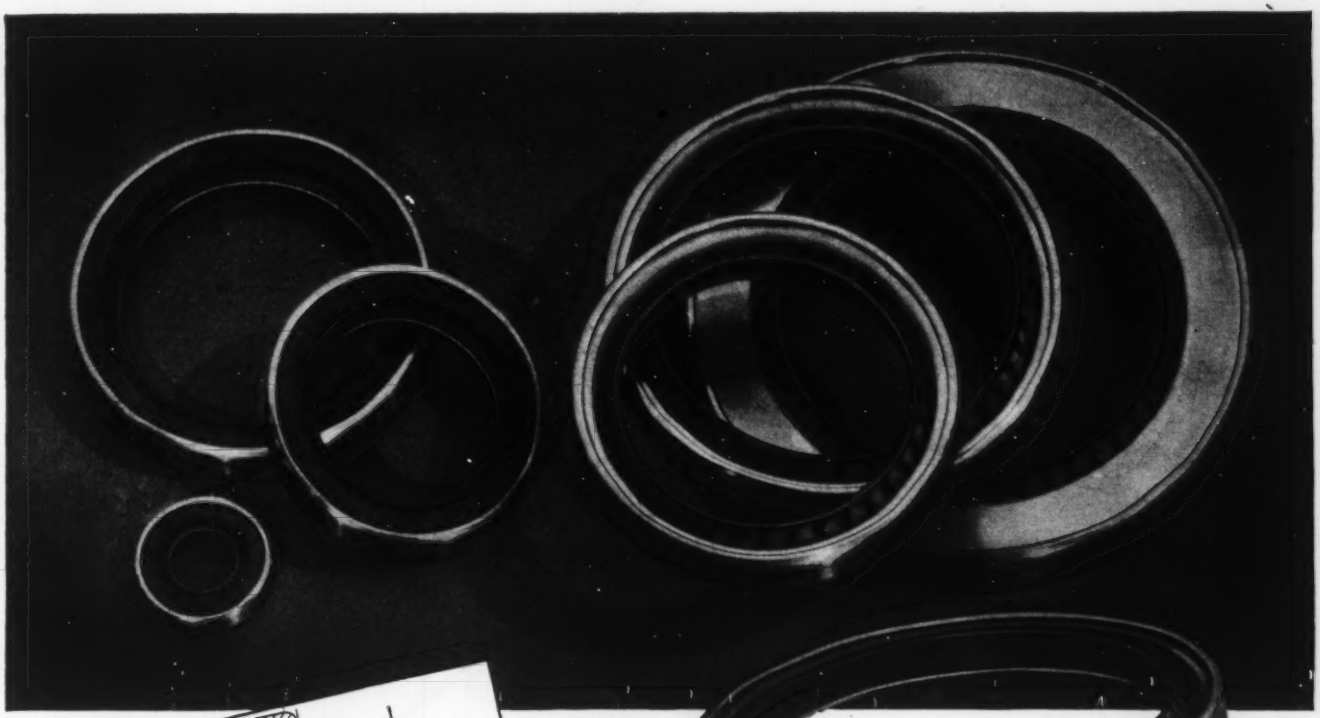
Transit parts like these have to be right on the button . . . and *stay* there. Even little changes in dimension throw you way off on a survey. That's why these parts are Alcoa Aluminum Die Castings. Cast to close tolerances, they change little in dimension and shape at elevated temperatures and under sustained load.

If permanence and stability can improve your product, lean on Alcoa's 34 years of die casting experience. You'll get all the design help you need. Start by getting your *free* copy of the engineer's handbook, "Designing for Alcoa Die Castings". Call your nearby Alcoa Sales Office or write ALUMINUM COMPANY OF AMERICA, 610 Gulf Bldg., Pittsburgh 19, Pennsylvania.

LIGHT METAL

ALCOA DIE CASTINGS

ALCOA ALUMINUM



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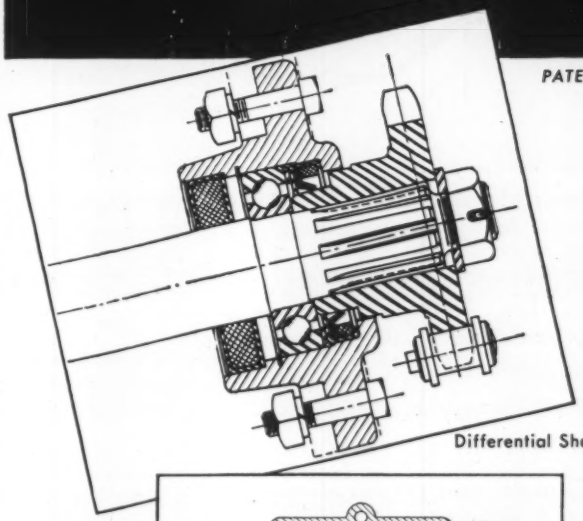
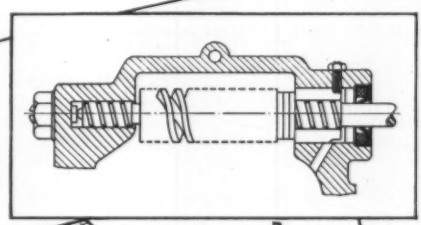
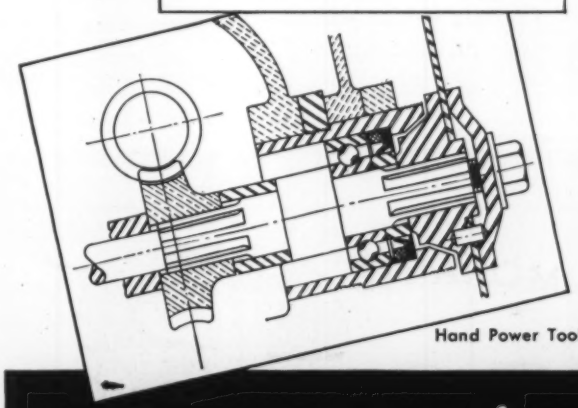


Differential Shaft



Small Worm Drive Shaft



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Models 53 and 63 KLOZURE OIL SEALS

for Extreme Sensitivity

Each finger or lug of the spring delivers independently its required light pressure to the tip of the sealing element. Its tempered flexibility does not deteriorate with age. This light, uniform, positive spring loading, combined with the tough, resilient sealing element, result in extreme sensitivity and long life of Models 53 and 63 KLOZURE Oil Seals. Specially recommended for shafts having considerable whip or lateral movement. Write for KLOZURE catalog.

THE GARLOCK PACKING COMPANY
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Garlock KLOZURE*

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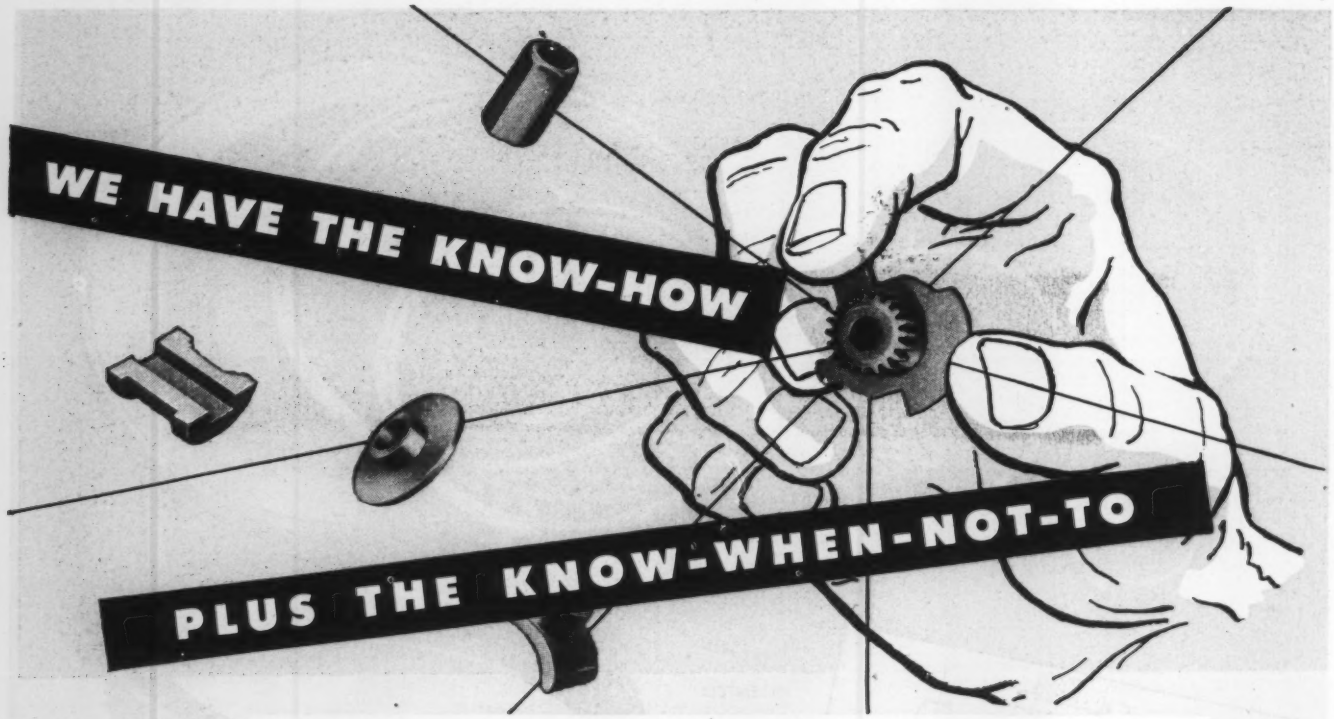


It is know-how, gained by diversified product experience and research, that equips us for the quantity production of top quality metal powder parts.

Just as important as knowing *how* to apply the art of powder metallurgy is to know when *not* to. That knowledge leads us to refuse orders to produce any part that cannot be made advantageously and economically by the metal powder process.

Of course, we gladly accept orders for items that meet our three basic requirements for efficient production:

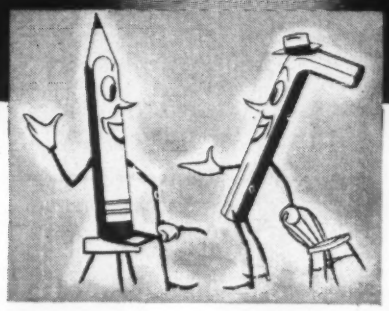
- The shape must permit good die fill and proper density.
- The required physical properties and tolerances must be within the range obtainable in normal factory production.
- The quantity ordered must be sufficient to justify the initial tooling costs.

What we mean is . . . we accept orders only when we know that the customer will be sure to obtain lasting satisfaction.

METAL POWDER PARTS BY MORAINE

MORAINE PRODUCTS

DIVISION OF GENERAL MOTORS, DAYTON, OHIO



They both prefer Bristol's Socket Head Cap Screws

Pencil: "With Bristol's Socket Head Cap Screws, designs can be more *compact*—small pockets, narrower flanges, etc.—because of the internal wrenching."

Wrench: "It's easier for the assembly man, too—particularly in hard-to-get-at places."

Pencil: "Bristol's Socket Head Cap Screws mean *flush* surfaces for better appearance and safety."

Wrench: "They take the wrench without fumbling or slippage—no danger of skid marks on the work."

Pencil: "The Class 3 fit produces a *lock-tight* engagement in the hole."

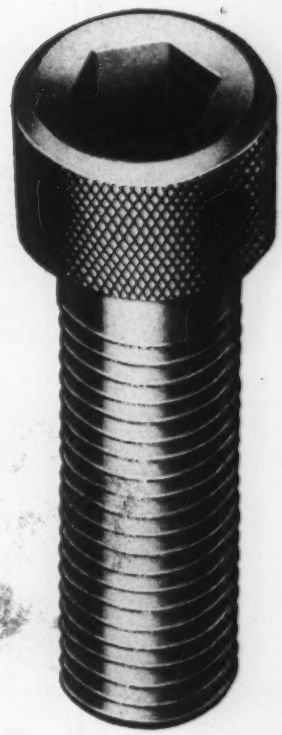
Wrench: "Bristol's Socket Head Cap Screws are *knurled* for easier starting, and they spin easily into place, fitting perfectly."

Pencil: "The great strength of Bristol's special alloy steel, heat-treated, means they can be tightened beyond the point where screws normally loosen due to shock and vibration."

Wrench: "And Bristol's 5-step inspection means that every one is a *perfect* fastener."

Bristol's Socket Head Screws are made in cap and set styles . . . regular Hex and Multiple-Spline socket . . . National Fine and National Coarse Threads . . . sizes from No. 4 wire to 1 in. diam. . . . various metals and finishes. Carried in stock by top distributors everywhere. Also, special shapes. Send for Socket Screw Catalog, addressing THE BRISTOL COMPANY, Mill Supply Division, 122 Bristol Road, Waterbury 91, Conn.

See us at Booth 866
TRIPLE MILL SUPPLY CONVENTION



Multiple-Spline and Hex Socket Screws . . . Cap and Set

BRISTOL'S

Only BRISTOL gives you the right Socket Screw for every application

SOCKET SCREWS

up to 1/3 less space...
improved windings...
plate steel protected...
WESTINGHOUSE
DO NOT LUBRICATE

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YOU CAN BE **SURE**.. IF IT'S

Westinghouse

—and NOW...

Needs No Lubrication

Now . . . for the first time . . . you can install electric motors, or motor-driven machines . . . and forget motor lubrication!

Westinghouse Life-Line . . . industry's amazing new, all-steel motor . . . now completely eliminates the biggest element in the maintenance of motors and motor-driven equipment . . . the need for periodic motor lubrication.

Eliminated, too, are two of the most frequent causes of motor burnouts and lost time . . . overgreasing and undergreasing of motors. Life-Line motors are equipped with sealed bearings, pre-lubricated with a more-than-ample supply of specially-treated lubricant.

Correct lubrication and long life are assured ...machine outages are reduced...motor drive problems are simplified, since motors can be located without need for constant accessibility.

Added to Life-Line's outstanding advantages of plate-steel protection, improved windings and more compact size, *pre-lubrication* is one more important reason for starting to convert, today, to Life-Line power. Standard ratings are available from stock—others on short delivery schedules. Ask your Westinghouse representative for price and delivery on your requirements, or write P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21527

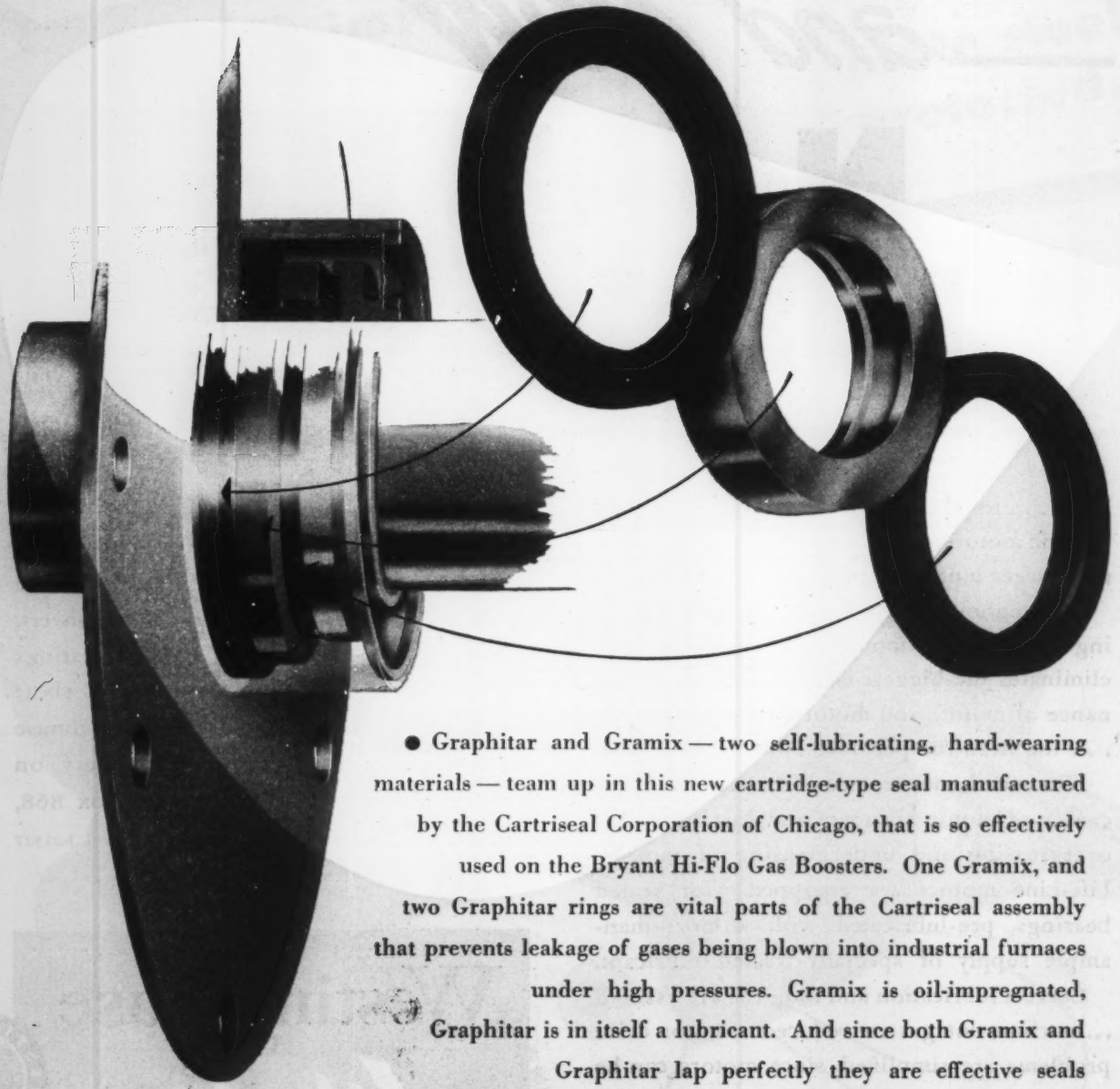
Westinghouse *Life-Line* Motors

WESTINGHOUSE

GRAPHITAR AND GRAMIX

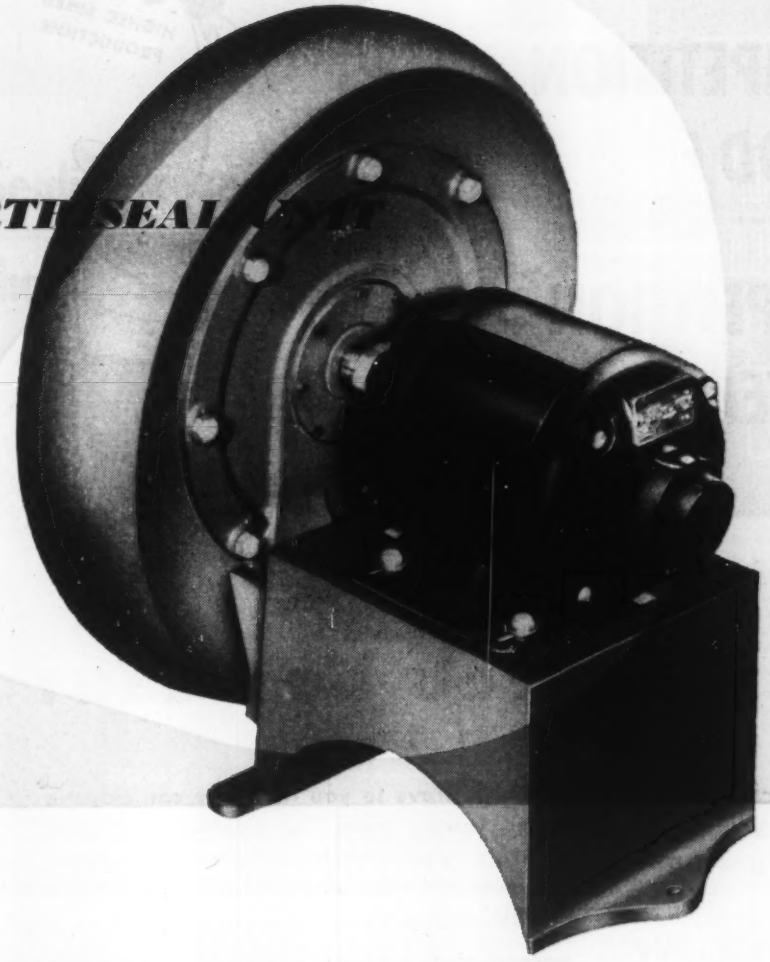
(CARBON-GRAPHITE)

form leak-proof seal on efficient new



● Graphitar and Gramix — two self-lubricating, hard-wearing materials — team up in this new cartridge-type seal manufactured by the Cartriseal Corporation of Chicago, that is so effectively used on the Bryant Hi-Flo Gas Boosters. One Gramix, and two Graphitar rings are vital parts of the Cartriseal assembly that prevents leakage of gases being blown into industrial furnaces under high pressures. Gramix is oil-impregnated, Graphitar is in itself a lubricant. And since both Gramix and Graphitar lap perfectly they are effective seals regardless of shaft speed and constant daily service.

THE UNITED STATES GRAPHITE COMPANY



GRAPHITAR AND GRAMIX are two unique materials that have found hundreds of uses in industry. Graphitar — a carbon-graphite material — is strong, extremely lightweight, self-lubricating, chemically inert and practically unaffected by temperature extremes. Graphitar can be finish ground to tolerances as close as .0005" in small sizes. Gramix parts are pressed powdered metal, oil-impregnated to require no additional lubrication, and finished with such precision that further machining is not required. Graphitar and Gramix may help solve a production problem for you. Send us your prints and we will be glad to make recommendations without obligation.

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

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BEATING COMPETITION *is BETTER!*

BARTH CAN HELP YOU DO BOTH!

It has been stated that machine tools designed today average 33⅓% more production than many designs built throughout the war.

If your plant is behind the procession, now is the time to realize that the place to meet and beat competition is on the production line . . . that's where you lick the problem of reducing costs . . . of meeting price competition . . . of lower break-even point . . . of higher profits.

The Barth Organization can help you meet the situation by designing and building for you special dies, tools and machinery that:—

1. **combine several operations**
2. **simplify complicated operations**
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4. **employ electronic, pneumatic, or hydraulic operation and controls**
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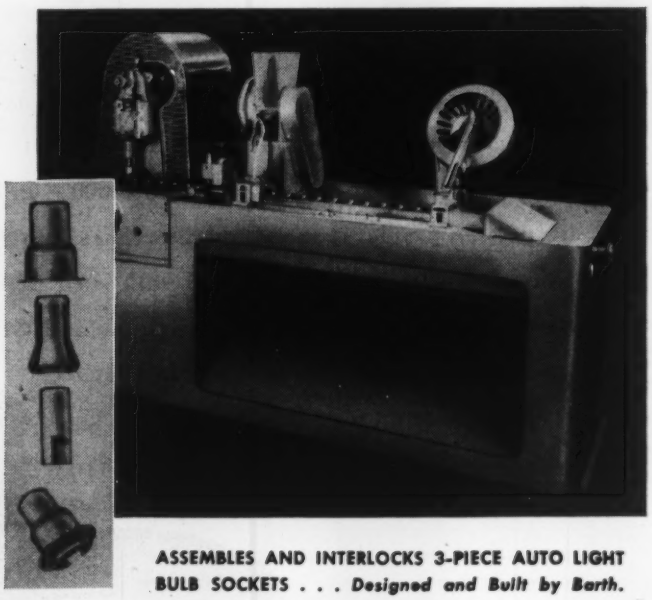
6. **re-design for better eye appeal.**

Let Barth prove to you that they can achieve better, faster, lower cost production in your plant . . . you'll not be obligated. Catalogue and case histories of Barth accomplishments mailed on request.



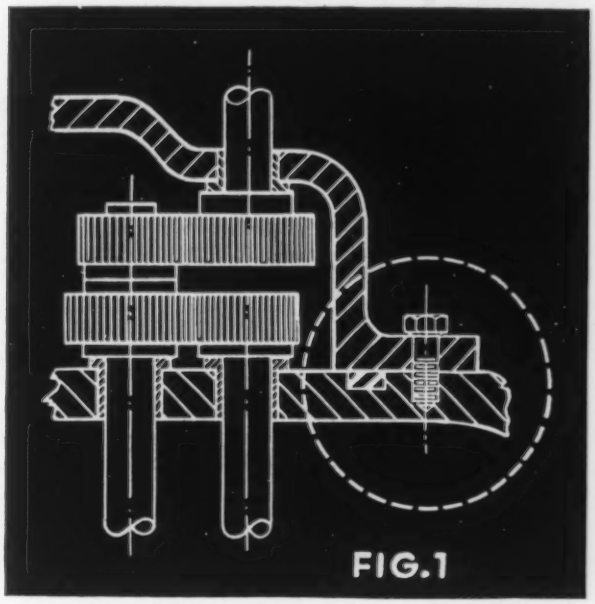
ASSEMBLES AND INTERLOCKS 3-PIECE AUTO LIGHT BULB SOCKETS . . . *Designed and Built by Barth.*

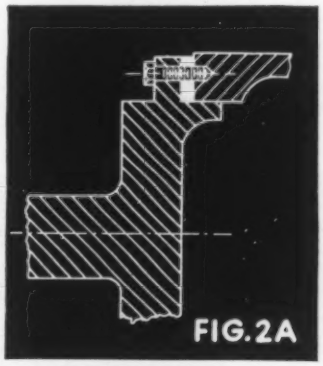
BARTH STAMPING & MACHINE WORKS Inc.

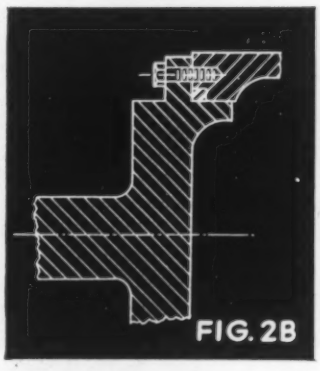
Denison at W. 34th St., Cleveland 9, Ohio

DESIGNERS AND BUILDERS OF DIES, TOOLS AND SPECIAL MACHINERY

Sealing cover plates that position internal parts







Where a removable cover plate positions internal parts, a metal-to-metal joint provides positive alignment and rigidity.

The most practical sealing material for metal-to-metal joints is one that is truly compressible. Truly compressible gaskets do not side flow under pressure. They deflect only in the direction of the applied load. Hence they won't extrude and interfere with correct mating of the flanges.

Typical of truly compressible materials, Armstrong's DC-100 Cork-and-Neoprene will compress up to 33% without appreciable side flow. And with most fluids, its resistance is equal to straight Neoprene.

Used to seal the flange in figure 1, DC-100 replaced a flat paper gasket. Variations in paper thickness had caused misalignment of internal parts. The confined cork-rubber gasket insures positive alignment and provides a lasting, oiltight seal.

The flanged journal of a calender roll was sealed by a flat rubber gasket as in figure 2a. Each time worn journals were replaced, however, lack of parallelism made a costly grinding operation necessary.

The journal, modified in figure 2b, permits quick, on-the-job replacement with positive alignment. The cork-and-rubber gasket seals coolants and compresses to permit perfect mating of the flanges.

Armstrong's cork-and-rubber is made with natural or synthetic rubber to obtain the desired solvent resistance. By adding calculated amounts of compressible cork to these non-compressible rubbers, Armstrong produces compounds in which side flow is controlled within specified limits.

Versatile cork and rubber may help solve your sealing problems. We suggest that you discuss your application with an Armstrong representative. He can suggest suitable materials and supply samples for experimental use.

Send for this gasket handbook

You'll find useful application and specification data in the new, enlarged 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date data on synthetic rubber, cork-and-synthetic-rubber, cork composition, and fiber sheet sealing materials.

This booklet includes ten technical discussions of the factors influencing modern gasket and joint design. It also suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries. Also included are typical applications and current government specifications.

For your free copy, fill in coupon at right and mail today.

ARMSTRONG CORK CO.
Gaskets and Packings Dept.
5104 Arch Street, Lancaster, Pa.

Please send me at once a copy of the new 24-page booklet, "Armstrong's Gasket and Sealing Materials."

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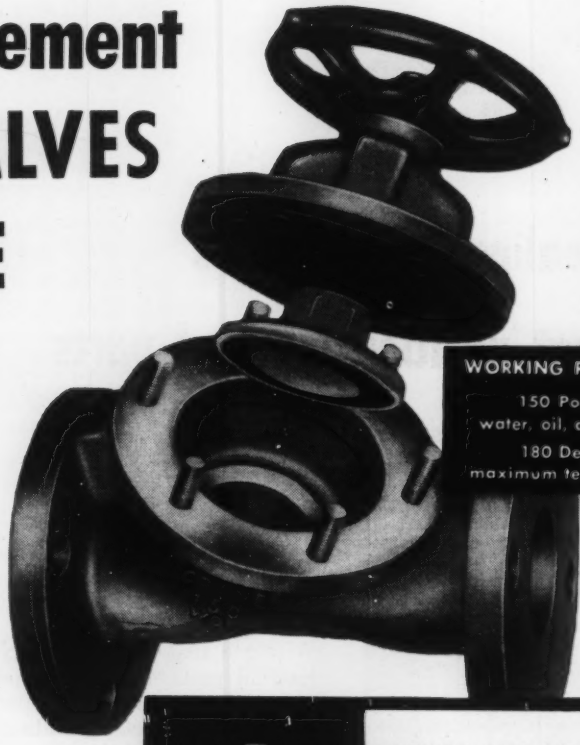
outstanding improvement in DIAPHRAGM VALVES by CRANE



WORKING PRESSURE:
150 Pounds
water, oil, air or gas
180 Deg. F.
maximum temperature

NEW SEATING ARRANGEMENT
MORE DURABLE...
SAFER...MORE EFFICIENT

The many outstanding advantages offered by new Crane Diaphragm Valves stem from basic improvements of the usual design. On Crane valves, the disc and diaphragm are separate. Each has but one function to perform, which helps to assure safer, more efficient, longer-lasting valve performance. Look over these exclusive Crane features.

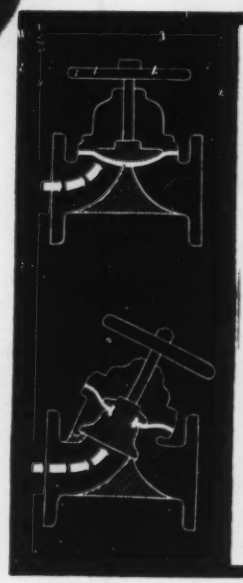
1. LONGER DIAPHRAGM LIFE, because diaphragm is used *only* to seal the bonnet—not for seating purposes.

2. POSITIVE SHUT-OFF in case of diaphragm failure. No other valve has this safety feature.

3. ACCURATE SEATING—new flat face disc with durable, resilient seating surface assures tight closure.

4. GREATER FLOW CAPACITY with reduced resistance and pressure drop, assured by Crane Y-pattern body design.

5. EASIER OPERATION—Crane separate disc and diaphragm construction takes less torque—fewer turns—to operate.



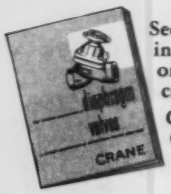
USUAL DESIGN

Diaphragm is used both to pinch off flow and to seal bonnet. Is subject to severe crushing against bridgewall, and rapid wear at point of seating. When diaphragm fails, valve can't be closed.

CRANE DESIGN

Seating of valve is independent of the diaphragm which serves only to prevent entry of line fluid into bonnet. Seating member is a separate circular disc firmly attached to stem and joined to diaphragm with a special leakproof connection.

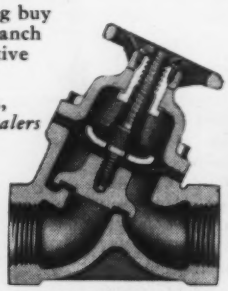
GET THIS DESCRIPTIVE CATALOG



See these new valves—the outstanding buy in their class—at your local Crane Branch or Wholesaler. Or write for descriptive catalog AD-1761.

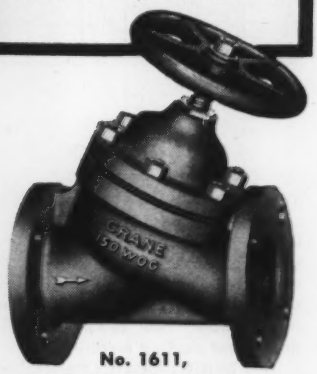
CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill. *Branches and Wholesalers Serving All Industrial Areas.*

This new Crane line includes iron valves with screwed ends in sizes ½ to 2 in.; with flanged ends from ½ to 4 in. Neoprene coated valves —flanged ends only—in sizes from ½ to 4 in.



No. 1610, screwed ends

No. 1615, flanged ends, neoprene coated



No. 1611, flanged ends

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VALVES
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PLUMBING
AND
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FOR EVERY PIPING SYSTEM

Two views of a steel mill table roll body cast of Meehanite Metal by the Shenango-Penn *Centrifugal* process, assuring exceptional life. Note exterior and interior machining. Shenango-Penn facilities include modern equipment for economical machine work of virtually every type and to any stage to best meet your particular needs.

Maybe you can profit by steel mill experience

THIS conveyor roll is going to save a steel mill some money. Because it is a Shenango-Penn *centrifugal* casting of Meehanite Metal, it will hold up longer than an ordinary roll . . . won't need replacement nearly so soon! That's good economy, don't you think?

Fundamentally that's why Shenango-Penn is producing symmetrical, annular and tubular parts, large and small, ferrous and non-ferrous, for many services in many industries. The Shenango-Penn *centrifugal* casting process results in more uniform, pressure-dense parts with finer grain, greater strength, superior wear resistance and freedom from sand inclusions and blow holes. Metal for metal, dollar for dollar, they do a better job. It pays!

As always, we welcome the chance to give you further evidence, specific facts, as to why it will pay *you* to specify Shenango-Penn. Send for a free bulletin on our ferrous or non-ferrous made-to-order centrifugal castings or on our *centrifugally cast* bronze bushing stock in standard sizes.

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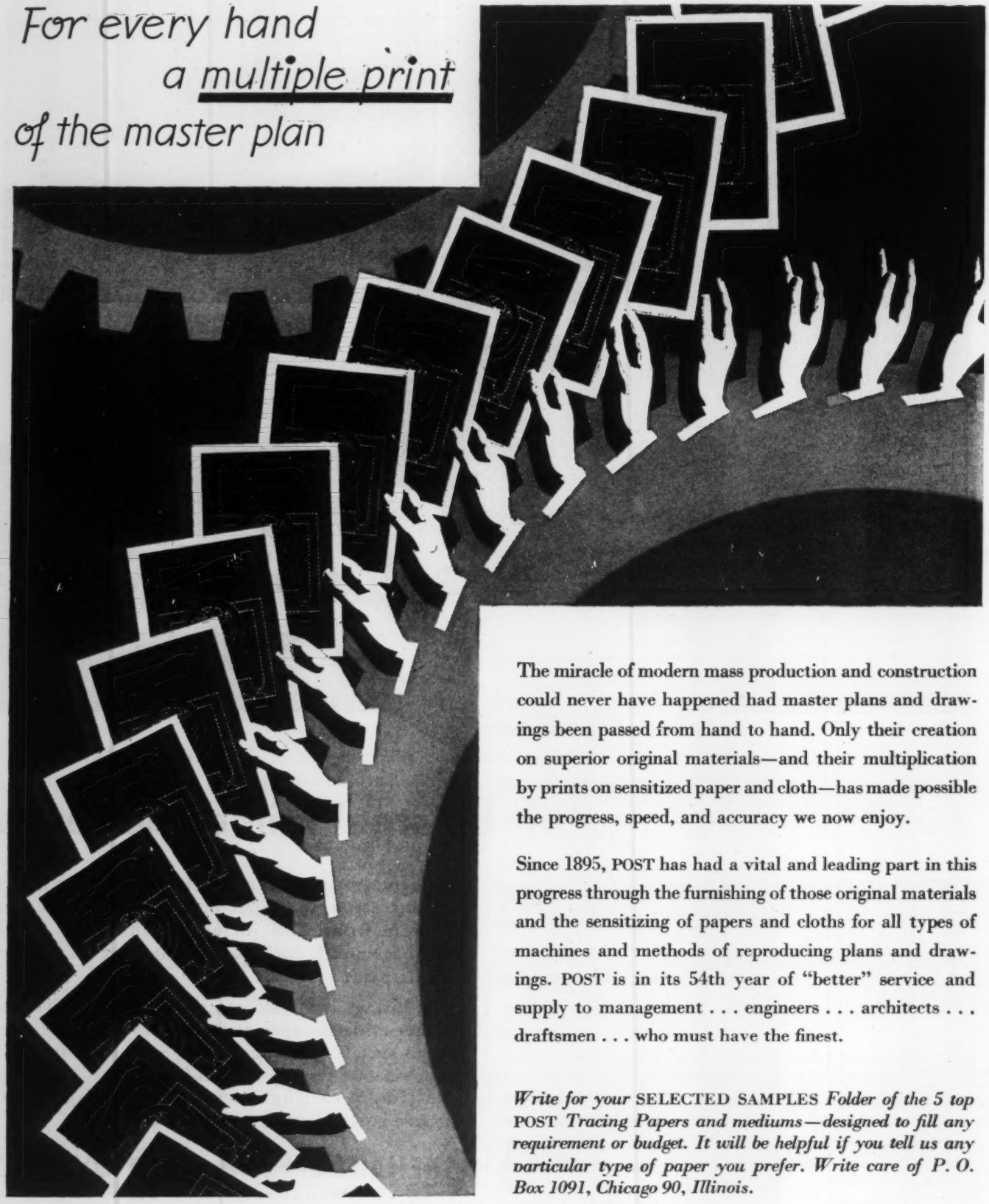
For every hand a multiple print of the master plan



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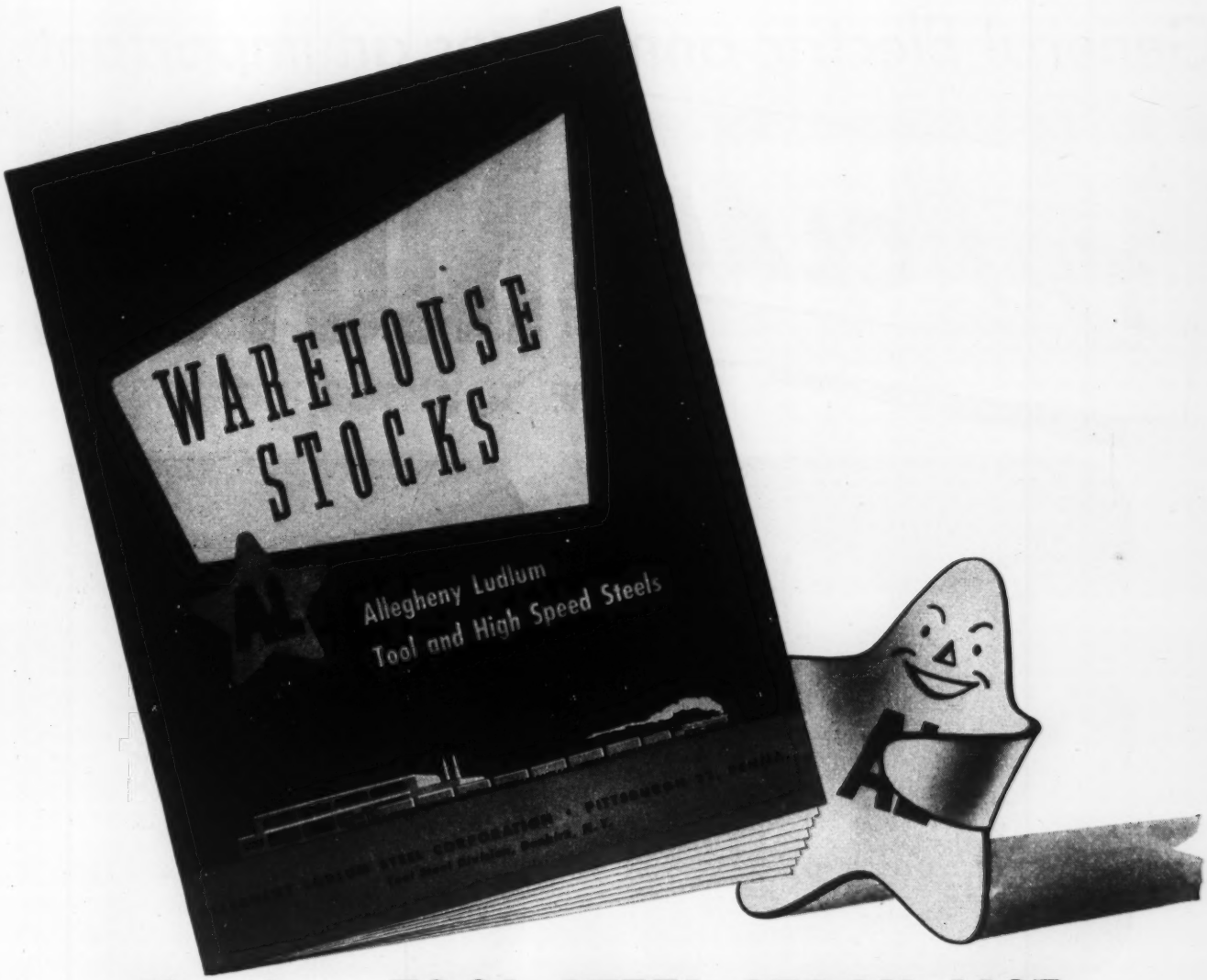

Here's a TOOL STEEL STOCK LIST that's really *Clear, Concise* and *Dependable!*

There's an A-L Tool Steel to do each job *best*

The Allegheny Ludlum Tool Steel family includes 37 principal types, covering the high speed, hot work, shock resisting, cold die, and carbon and low alloy steel fields. Let us help you find the best answer to *any* problem that occurs in your production or use of cutting and forming tools.

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This 72-page catalog lists the stocks of A-L High Speed and Tool Steels which are constantly maintained in each of 18 warehouses, located at convenient points from coast to coast. In compact, easy-to-follow style, the book gives a complete stock picture, nationwide, of the 15 most widely used types of these steels—each in a full range of standard shapes and sizes—and also includes data on stocks of drill rod, tool bits and Carmet carbide metal blanks and tools.

It may be that your requirements call for mill shipments. If so, you can rely on us to schedule material for you without delay. *But*—if you depend entirely or in part upon ordering High Speed and Tool Steels in smaller lots—and want to know where you can get them *quickly*—you'll find A-L's book of "Warehouse Stocks" mighty handy to have in your desk. ● Write for your copy *today!*

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Pittsburgh, Pa.

TOOL STEEL DIVISION: DUNKIRK, N. Y.

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WBD 1781

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TRI CLAD MOTOR

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IF YOU HAVE Tri-Clad motors in your plant, your records will prove our statement: *"you can't beat Tri-Clad extra protection."* On 2 million motors, the Tri-Clad nameplate stands for extra protection against industrial hazards. *NOW it means even more.* For Tri-Clad motors are now backed by an exchange service designed specifically to cut down-time and eliminate the need for extensive motor-repair facilities. The Tri-Clad Motor Exchange Plan is important news to all industry.

GENERAL ELECTRIC now maintains 16 motor exchange centers in principal industrial areas across the country. Each center is prepared to make an immediate exchange of Tri-Clad motors—popular types, open (dripproof) 4-pole, 1 to 5 horsepower—during the first five years of service. Exchange motors have been reconditioned and tested under actual factory conditions. Each carries a new-motor warranty. The cost ranges from nothing for motors in service one year or less to a nominal fee based on the age of your motor.

Look for this EXTRA on the motor you buy

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GET extra down-time protection

REDUCE "spare-motor" inventories

GENERAL ELECTRIC

new service to industry...

EXCHANGE PLAN

for popular sizes, 1 to 5 hp

YOUR MACHINERY BUILDER can now give you added assurance of operating continuity in the machinery he equips with Tri-Clad motors. If you look to him or his agents for motor repairs or replacements he'll be better prepared than ever to give you fast, one-call motor exchange service—a welcome extension of the General Electric fractional-hp motor exchange service to integral-hp open (drip-proof) motors.

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General Electric Company, Section C756-1
Apparatus Dept., Schenectady 5, N. Y.

YES! I want the full story on your new Tri-Clad Motor Exchange Plan. Please send me Bulletin No.

☐ GEA-5189 For Motor Users
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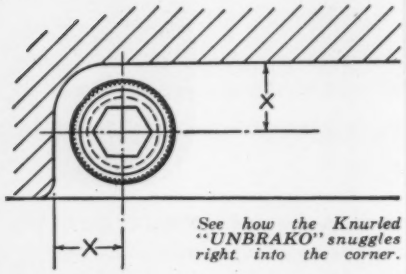
Knurling of Socket Screws originated with "Unbrako" in 1934.

for compact designs . . . space and weight saving . . . faster assembly

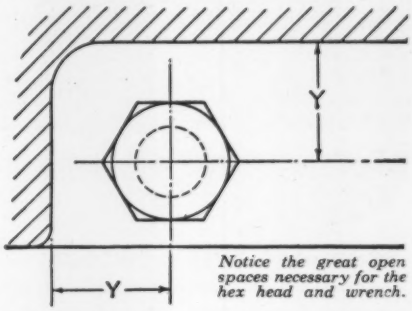
KNURLING (an exclusive "UNBRAKO" feature) on the *head* of the "UNBRAKO" Socket Cap Screw speeds assembly. KNURLING on the *threads* or *points* of our patented "UNBRAKO" Socket Set Screw provides self-locking—"they positively won't shake loose!" In fact, almost any set screw application can be locked with our patented "UNBRAKO." Furthermore, internal wrenching promotes compact design—saves space, weight and material, reduces costs.

When next you need screw products, remember, "It pays to specify and insist on "UNBRAKO!"

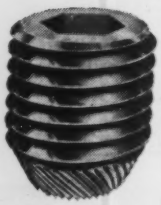
Write for the name and address of your nearest "UNBRAKO" Industrial Distributor and your copy of the "UNBRAKO" Catalog.



See how the Knurled "UNBRAKO" snuggles right into the corner.



Notice the great open spaces necessary for the hex head and wrench.



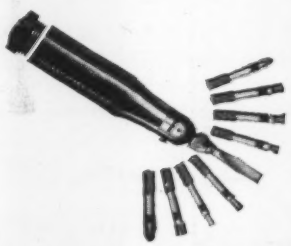
Pat'd and Pats. Pend.

The "UNBRAKO" Socket Set Screw with Knurled Cup Point positively will not shake loose, regardless of the most chattering vibration.

Pat'd

The "UNBRAKO" Self-Locking Socket Set Screw with Knurled Thread for flat, full-dog, half-dog, cone, oval point and for use on hardened shafts. "It won't shake loose!"

"UNBRAKO" Socket Set Screw with Plain Cup Point for use where Self-Locking is not necessary.



Kits: Pats. Pend.

"HALLOWELL" Key Kit. You can't tighten or loosen a socket screw without a hex socket wrench, so why not get our No. 25 and No. 50 Hollow Handle Key Kit which contains almost all hex socket bits.

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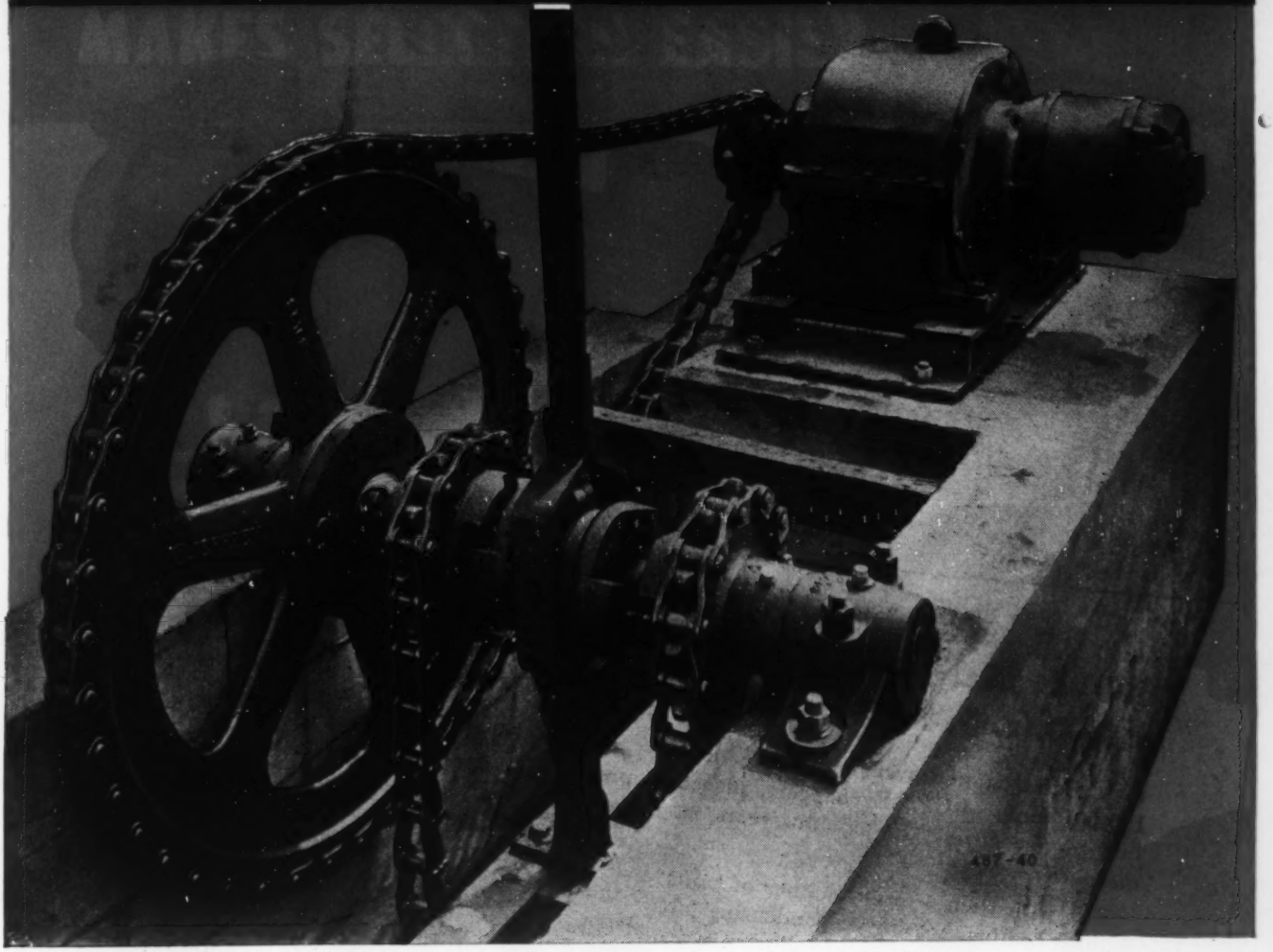

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THE WORLD'S *Most Versatile* EXCHANGER

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So whether you're a builder of primary equipment, furnishing exchangers with your units as original accessories, or whether you're an actual user of heat transfer equipment, you can be sure of more BTUs transferred per dollar invested with a mass-produced "BCF" than with any other exchanger.

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Eight pages illustrate and summarize your benefits from the new "BCF". Ask for Bulletin 1.1K1 on your letterhead.

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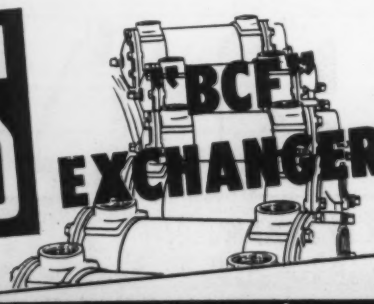

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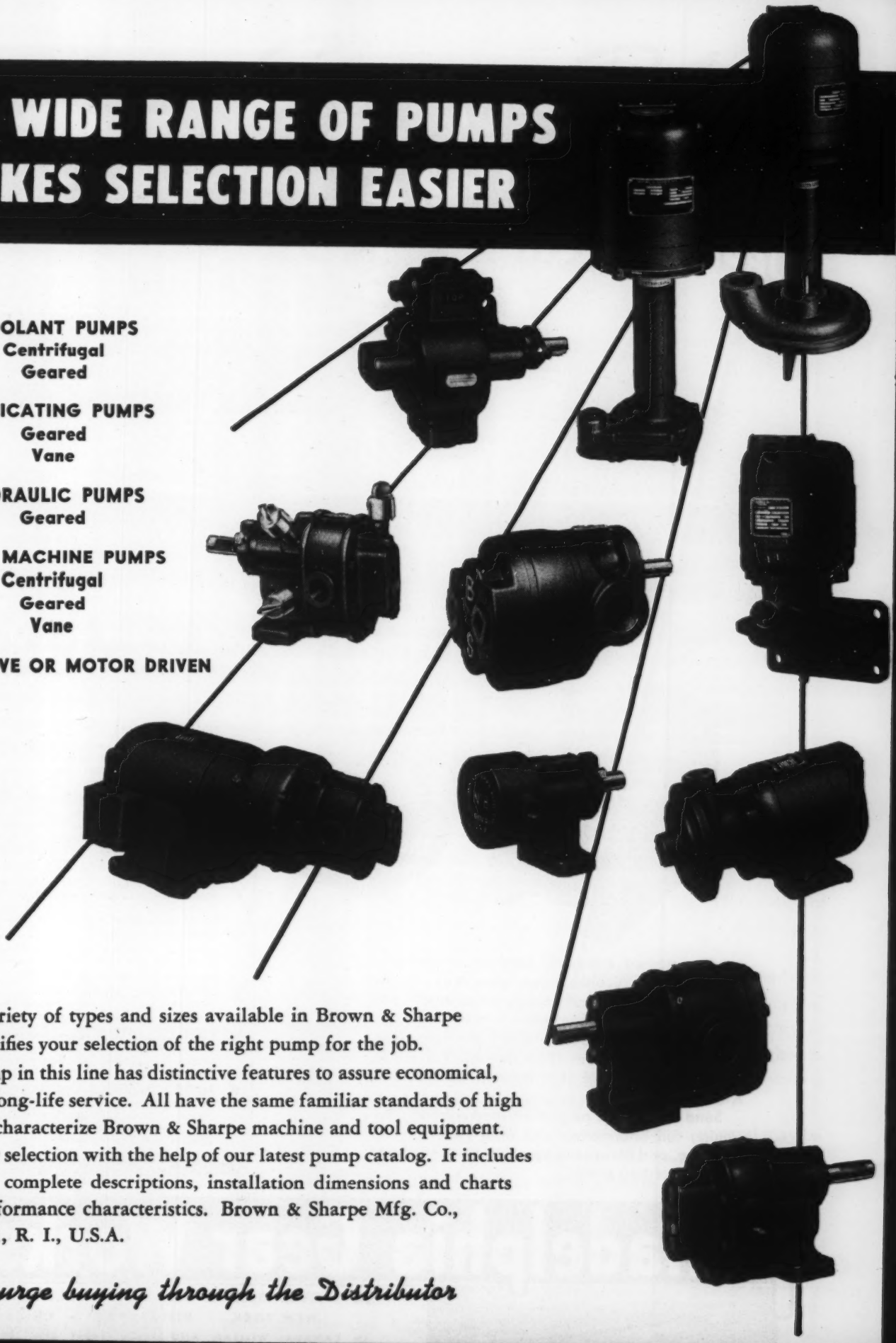

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The wide variety of types and sizes available in Brown & Sharpe Pumps simplifies your selection of the right pump for the job.

Every pump in this line has distinctive features to assure economical, dependable long-life service. All have the same familiar standards of high quality that characterize Brown & Sharpe machine and tool equipment.

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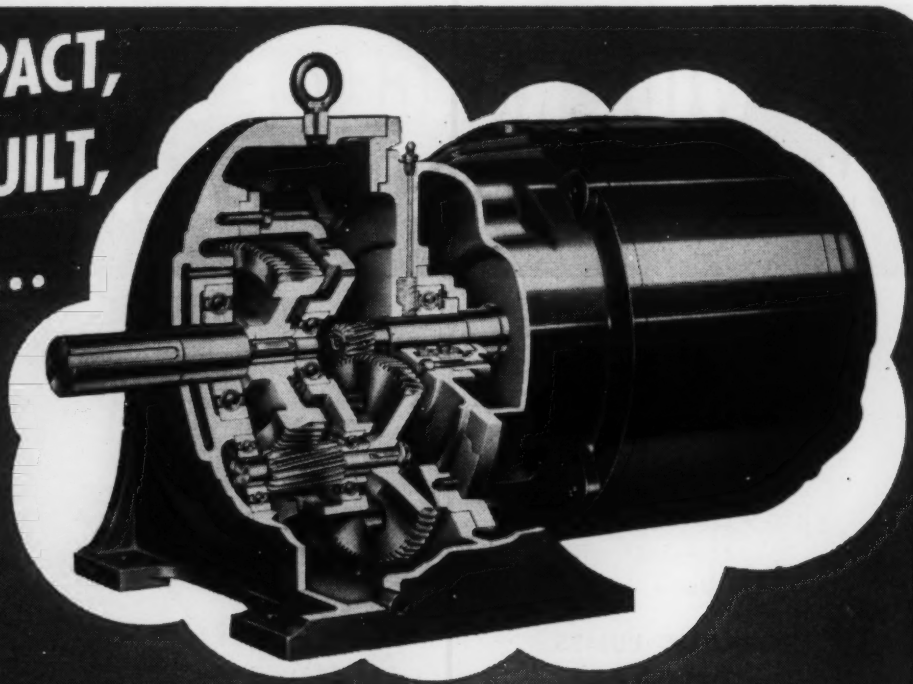

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- ✔ **UNLIMITED ADAPTABILITY**—Available in single, double and triple reductions to provide a wide range of speeds with motor ratings from 1 to 60 hp. NEMA "D" type flange mounting permits use of any type enclosure in A-c or D-c motors.
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- ✔ **BALANCED, INTEGRATED DYNAMICS — FOR STRENGTH**—Design of gear unit in the higher ratios lends triangular stability based on Balanced, Integrated Dynamics. High grade grey iron cast frame gives added strength and shock resistance.
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- ✔ **POSITIVE LUBRICATION**—Splash system with large oil reservoir assures thorough and constant lubrication of all parts of gear unit. Leak-proof housing. Motor, greased independently, has double-shielded ball bearing design.

A self-contained, *extremely compact* unit that conforms to the recommended standards of the American Gear Manufacturers Association and National Electrical Manufacturers Association. . . . Available in single, double and triple reductions. . . . Range of speeds: 780 through 7.5 R.P.M. Motor Rating from 1 H.P. through 60 H.P. . . . A-c or D-c.

Send for new 42 page illustrated catalog, containing full information and data necessary for ordering, and please use your Business Letterhead when requesting same.

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Industrial Gears and Speed Reducers
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Seeing is Believing
IN METALLURGY

HERE ARE TWO PICTURES OF THE SAME THING . . . above a section of Tobin Bronze* Rod. At right a micrograph at 75 diameters of a polished and etched specimen cut from the rod. *Reg. U. S. Pat. Off.

YOU'LL FIND few better examples of precise workmanship and careful selection of materials than this latest model of the Bausch & Lomb Research Metallograph. With this precision instrument a skilled laboratory technician may examine and photograph metal structure at high magnification. To build it Bausch & Lomb use 61 parts made from seven Anaconda Copper Alloys. Eight parts are formed from tube, 16 from strip and 37 from rod.

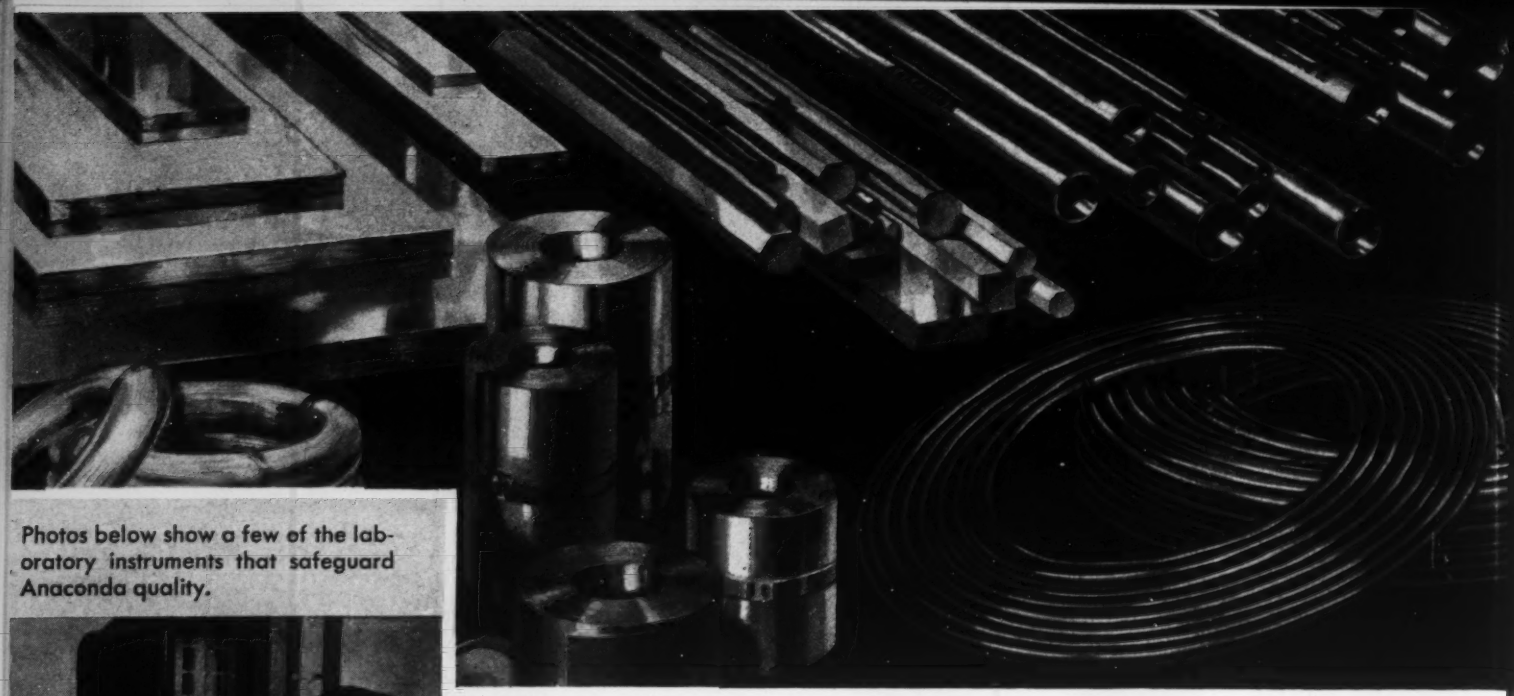
Of what advantage are these alloys? First, they provide accurate, smooth surfaces on delicate working parts. They lead to production economies through higher speeds and longer tool life. Availability of just the right alloy for a specific purpose is typified by the use of Anaconda Alloy 243 (with low lead content) for parts requiring knurling. Also there's ease and economy in applying finishes such as light-absorbing matte-black, or gleaming chromium plate.

Manufacturers in general may be sure that the wide range of Anaconda Metals will blanket their needs. You can depend on the right composition, temper and grain size for a given part, whether it is to be machined, forged, rolled, spun, stamped, pressed, coined, upset or drawn. Next Page Please . . .

ANACONDA

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut



Photos below show a few of the laboratory instruments that safeguard Anaconda quality.

A.R.L. Densitometer-Comparator

Evelyn Photo-Electric Colorimeter

Picker X-ray Diffraction Unit

Grain Size Comparator

Quality Control

AT THE MILLS

EXTENSIVE, routine use of the new Bausch & Lomb Research Metallograph (described on preceding page), and many other tools of modern metallurgical research, assures the utmost uniformity and dependability in Anaconda Copper and Copper Alloys.

At the turn of the century, The American Brass Company, already the largest fabricator of copper and copper alloys, led the way in the search for greater metallurgical knowledge, and instituted laboratory control of alloy compositions to replace the father-to-son methods of mixture determination that had prevailed from the beginnings of the industry.

From that day on, the activity and responsibilities of the Technical Department have grown with the rapid advance of technical knowledge and instrumentation. Today more than half a million tests are made annually in the course of maintaining laboratory control over all mill operations and practices.

Such planned research and routine quality control is your assurance of Anaconda Metals that will fully meet your manufacturing requirements.

48118

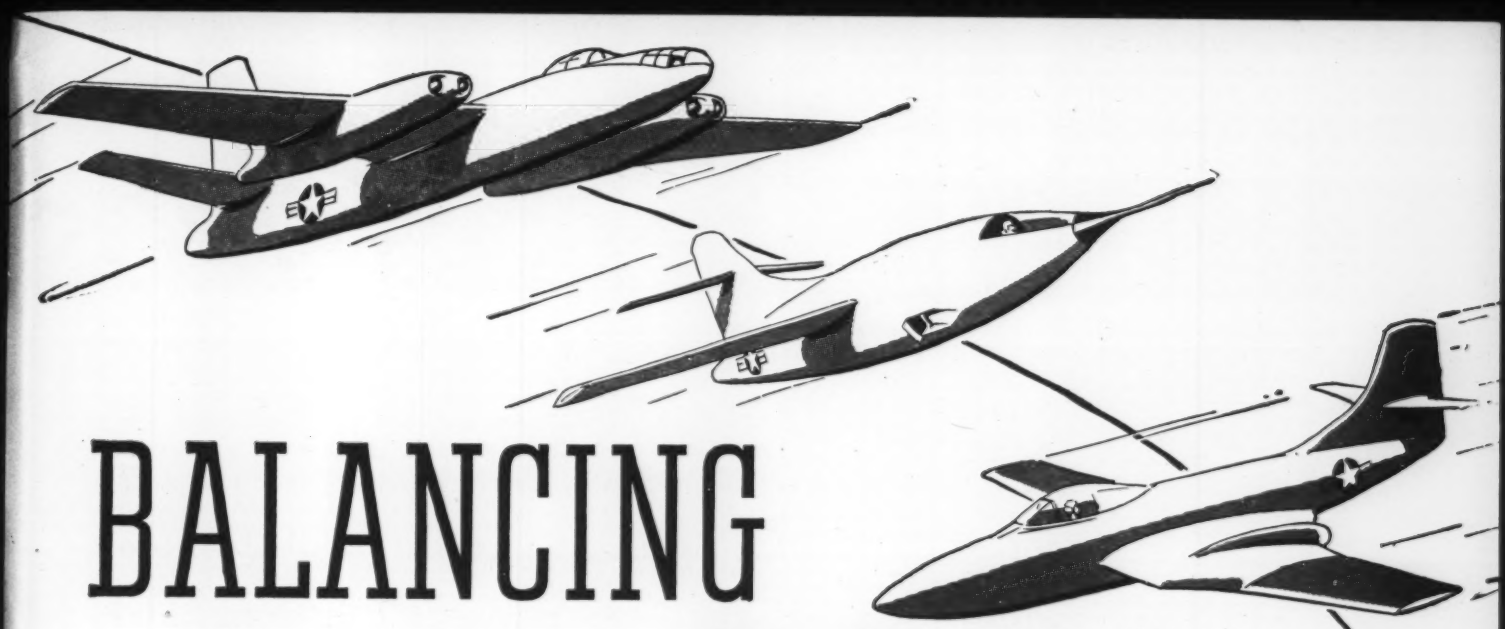
THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

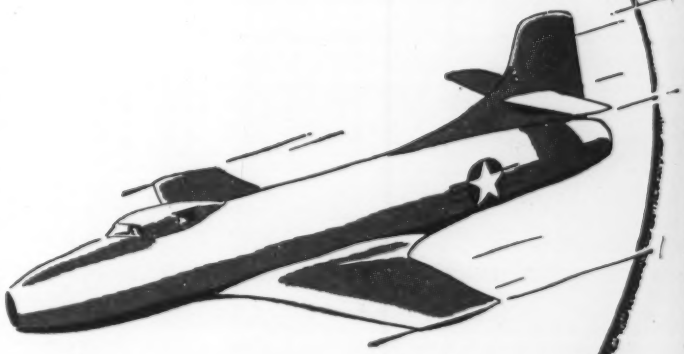
In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

***Anaconda* COPPER and COPPER ALLOYS**



BALANCING

keeps pace with the jets!

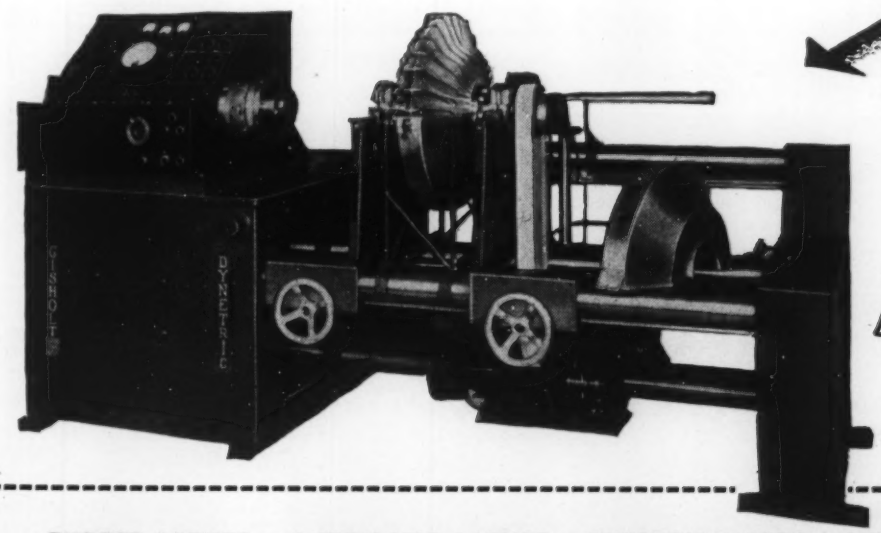


Racing into the terrifying regions bounded by the speed of sound, the jet planes have also opened new frontiers in engineering. For example, the requirements for accurate balancing exceed all previous commercial standards. At the fabulous operating speeds of the turbo-jet impellers, the slightest vibration caused by unbalance can spell disaster.

It is significant that builders of American jet engines have turned to Gisholt Balancers for the unfailing accuracy required in this important work.

GISHOLT MACHINE COMPANY

Madison 10, Wisconsin



Gisholt DYNETRIC Type U Balancer, shown at left, can measure unbalance vibrations as small as 20 millionths of an inch on these turbo-jet compressor impellers.

DYNETRIC BALANCERS — GISHOLT

DEVELOPED JOINTLY WITH WESTINGHOUSE ELECTRIC CORPORATION
"DYNETRIC" IS A TRADE MARK REG. U. S. PAT. OFFICE BY WESTINGHOUSE ELECTRIC CORPORATION

TURRET LATHES • AUTOMATIC LATHES • SUPERFINISHERS • BALANCERS • SPECIAL MACHINES

ONLY REEVES *gives*

1. Variable Speed Transmission. 2. Vari-Speed Motor Pulley. 3. Vari-Speed Motodrive. Each with its own specific field of application to assure accurate, infinite speed control for every type and make of driven machine.

Today, more than 2,100 different makes of production machines offer REEVES Speed Control as standard equipment. One reason for this marked preference for REEVES is the fact that REEVES, *alone,* makes a *complete* line of speed control units from which the machine designer and builder can choose the unit which measures up in *every* detail to the specialized requirements of *each individual machine.*

The REEVES line of variable speed drives consists of three basic units . . . each one designed for its own specific field of application . . . but all incorporating the same time-tested REEVES operating principle, proved in more than 265,000 installations in virtually every industry. Each of these three basic units, in turn, is available in a wide range of designs, sizes, capacities, speed ratios and controls.

In selecting the speed control equipment that will be standard equipment on your machines, make sure you choose the unit that will provide *exactly* the right speed for every operation and every operator under every changing condition . . . *make sure you choose* REEVES!

Call upon the REEVES field engineer nearest you for assistance in studying your particular speed control problem and selecting the correct unit. Also write for the catalog giving full details on the *complete* REEVES line—No. H5-450A.

What Your New Machines Can Accomplish with REEVES Speed Control

1. **Handle more sizes, shapes and materials.**
2. **Match variances in number or skill of operators.**
3. **Compensate for change in consistency, density or viscosity of materials in process.**
4. **Accurately control heating, baking, drying, cooking or chilling time.**
5. **Maintain uniform peripheral speed (or tension) on decreasing or increasing diameters.**
6. **Maintain uniform pressure, weight, liquid level, temperature and other variable elements.**
7. **Regulate conveyor speeds—even to fractions of an inch per minute.**
8. **Synchronize all working parts—of one machine or machines operating in series.**

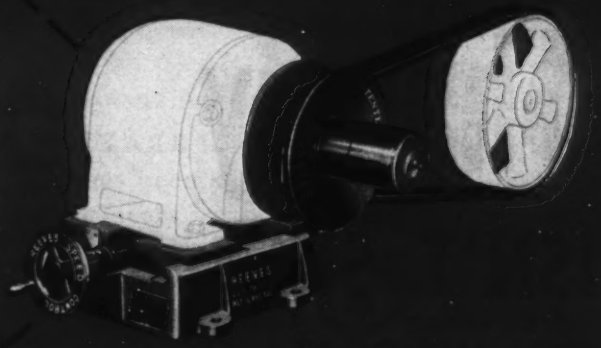
REEVES PULLEY COMPANY • COLUMBUS, INDIANA

Recognized Leader in the Specialized Field of Speed Control Engineering

you a "choice of 3"*

* **Transmission** (left), extremely rugged in construction, is especially desirable for installations where the demand is for heavy-duty service, higher horsepower output, wide speed range, automatic control, etc. "Internal operating parts" ideal for incorporation within the machine framework as standard equipment. Transmission provides infinite, accurate speed flexibility over a range of 2:1 to 16:1. Sizes—fractional to 87 hp.

* **Motor Pulley** (right), most practical in installations calling for economy, limited speed range, ease of installation, low horsepower output, etc. Provides an instantly variable speed drive within 4:1 ratio for any constant speed motor. Sizes to 10 hp.

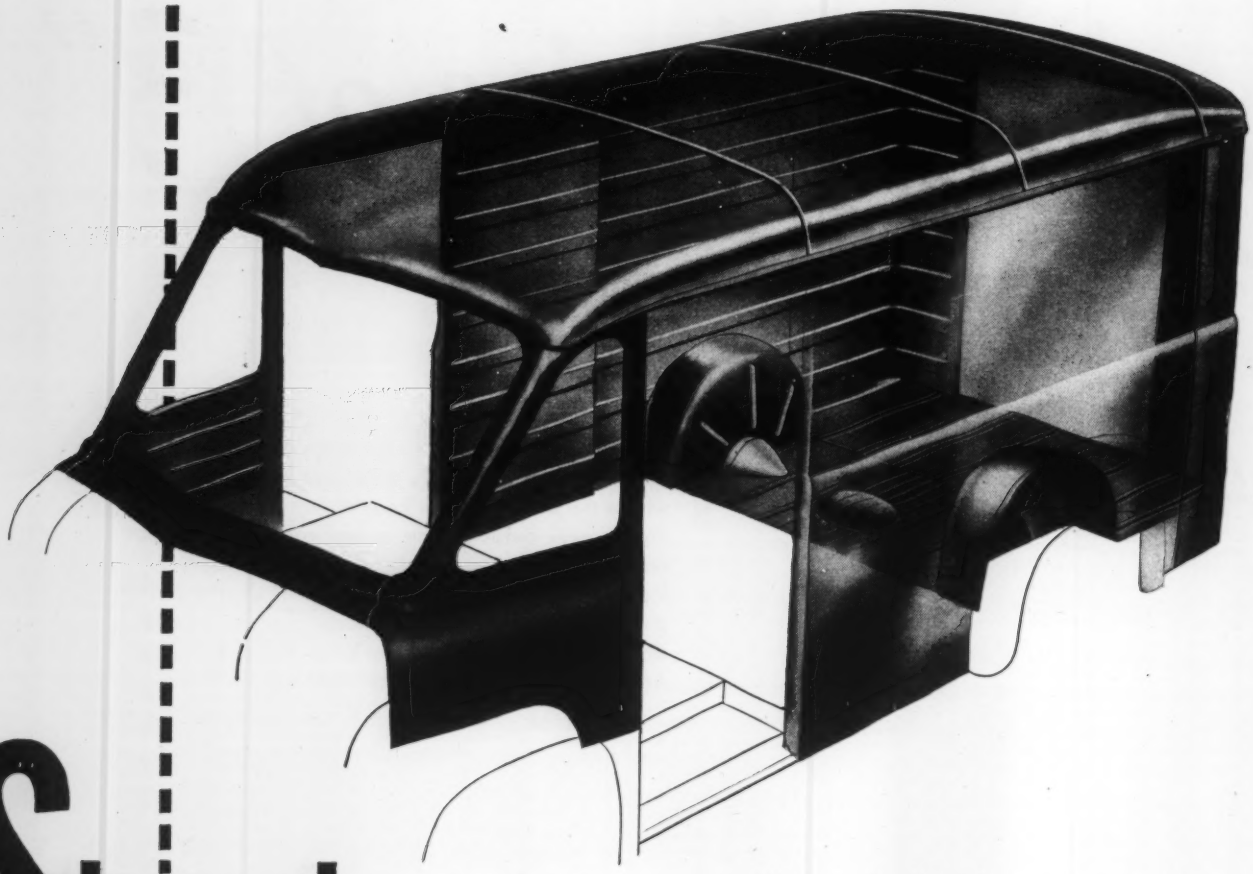


* **Motodrive** (left), ideal for installations indicating compactness, low output speeds, etc. Combines motor, speed varying mechanism and reduction gears in single unit. Speed variations 2:1 to 6:1 inclusive. Sizes to 20 hp.

ACCURATE • VARIABLE

Reeves Speed Control

GIVES THE RIGHT SPEED FOR EVERY JOB!



Shapely ISN'T SHE?

WHEN IT'S GOTTA FIT—

That goodlooking shape you see represents a composite of heavy automotive stampings. "She's" a picture of the parts now being turned out on Brandt's precision mass production line for one of America's largest automotive manufacturers. A battery of huge presses, a plant equipped to meet exacting specifications and rigid delivery schedules at distant assembly lines, these plus skilled workmanship are serving industry at Brandt. Ample stockpiles, complete engineering, transportation and expanded production facilities combine to make Brandt a strategic "extra plant" when you need it. At Brandt, all inquiries are handled from receipt to quotation by the Engineering Department. We invite *your* inquiry.

BRANDT BALTIMORE *measures up!*

TO EXACTING METAL WORKING SPECIFICATIONS

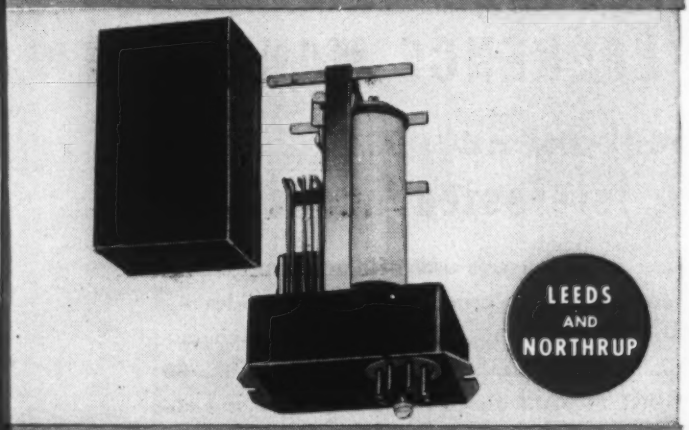
METAL STAMPINGS - HEAVY WELDMENTS - PRESSED STEEL SHAPES

CHARLES T. BRANDT, INC. 1700 RIDGELY ST. BALTIMORE 30, MD.

"Can you give us a relay that..."

RCA turns to CLARE for a "relay we can install and forget" for Electron Microscope.

CLARE provides a precise operating relay, capable of long and reliable operating life, to meet the needs of this RCA precision instrument.



"Give Us a Dust-Tight Relay for Dusty Locations" — said LEEDS & NORTHRUP.

Radio plug mounted, with terminals brought through dust-tight Neoprene gasket and with dust-tight steel cover, this CLARE relay solved a LEEDS & NORTHRUP problem.

CLARE Relays in WESTERN UNION "Push-Button" High-Speed Switching System.

CLARE provides thousands of small relays of maximum reliability to meet exacting requirements of Western Union's high-speed communications program.

Tough relay problems are everyday routine with CLARE engineers

CLARE customers include some of the biggest names in the American industry . . . and many smaller concerns . . . whose engineers have sought and found in CLARE experiment and research the answer to unusual and difficult relay problems.

The decision to "put it up to CLARE" often saves untold hours of experiment, trial and error and sometimes costly delays. Many who get in touch with CLARE find our engineers have already solved their problem for somebody else.

CLARE leadership in the industrial relay field has been achieved by the ability of CLARE engineers to approach any and all relay problems with a completely open mind. No problem of relay size, shape or operating characteristics but finds them ready and anxious to cooperate in its solution.

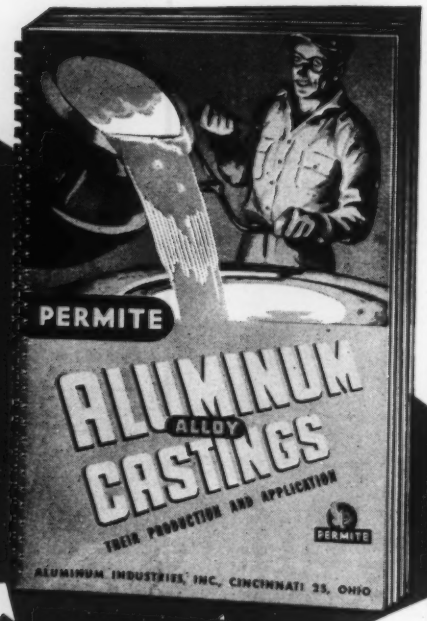
There is a CLARE sales engineer located near you . . . as close as your telephone. If your problem involves relays, why not take advantage of CLARE experience with every type of relay requirement. To do so may easily save you time and expense. Look for CLARE in your classified telephone directory, or write: C. P. CLARE & Co., 4719 West Sunnyside Ave., Chicago 30, Illinois. In Canada: Canadian Line Materials, Ltd., Toronto 13. Cable address: CLARELAY.

CLARE RELAYS

First in the Industrial Field

Here's help on your

ALUMINUM CASTINGS PROBLEMS



VALUABLE NEW REFERENCE MANUAL

Sent on Request to Interested Executives

Full of Facts and Data You Can Use

Advantages of Aluminum
When you should use —
- Sand Castings
- Permanent Mold Castings
- Die-Castings

Use of Different Alloys for Desired Qualities
Heat Treatment for Added Tensile and Yield Strength and Hardness
Design Principles
Quality Control
Finishing Methods

EVERY user or prospective user of aluminum castings will find cost reduction or product improvement ideas — or both — in this new manual on the production, characteristics and uses of aluminum castings. It contains 80 pages of facts and data useful to management and engineering executives interested in product improvement through the use of aluminum castings of the right type and design.

In chapter after chapter it discusses production methods, alloy uses, design principles, and other factors important to obtaining the desired casting quality for each specific end use requirement.

This complete reference data book is offered by the Engineering Department of Aluminum Industries to those manufacturers interested in obtaining the best value in aluminum castings to meet their specific parts requirements. Recommendations and estimates on your castings requirements also submitted upon request. Write us today.

PERMITE

ALUMINUM INDUSTRIES, INC.

CINCINNATI 25, OHIO

ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS

HURRICANE!

How violent? Where heading? How fast?

Hurricane warnings that save so many lives on land and sea—where do they come from? From seismograph recorders, perhaps better known for their earthquake-locating power. These sensitive instruments, stationed all over the country and on Atlantic and Pacific island outposts, locate and plot the minute-by-minute movement of violent atmospheric disturbances . . . and pen the vital data on tape.

The heart of each of these life-savers is a Telechron Timing Motor . . . *instantly, constantly synchronous.* No other motor could be trusted with the tremendous responsibility of feeding facts to the scientists who dedicate their time and talent to this most important work.

Have you a timing problem?

What variable factors do you want to control or record with split-second accuracy? The chances are that the correct application of a standard Telechron Motor is the answer to your problem. A Telechron Application Engineer can quickly tell you. Consult him early in your planning and save time and trouble. In the meanwhile, fill in and mail the coupon below today for up-to-the-minute facts about Telechron Synchronous Motors.

Telechron®

ALL TELECHRON TIMING MOTORS ARE

INSTANTLY . . . CONSTANTLY SYNCHRONOUS

Telechron Inc. A General Electric Affiliate
20 Union Street
Ashland, Massachusetts

Please send me information on Telechron Synchronous Motors (maximum torque: 2 pound inches at 1 rpm). My possible application is:

- ☐ Instruments
- ☐ Timers
- ☐ Electric Appliances
- ☐ Cost Recorders
- ☐ Advertising, display items
- ☐ Juke Boxes
- ☐ Air Cond. & Heat'g Controls
- ☐ Communications Equipment

Other (please fill in)

- ☐ _____
- ☐ _____
- ☐ _____

NAME_____

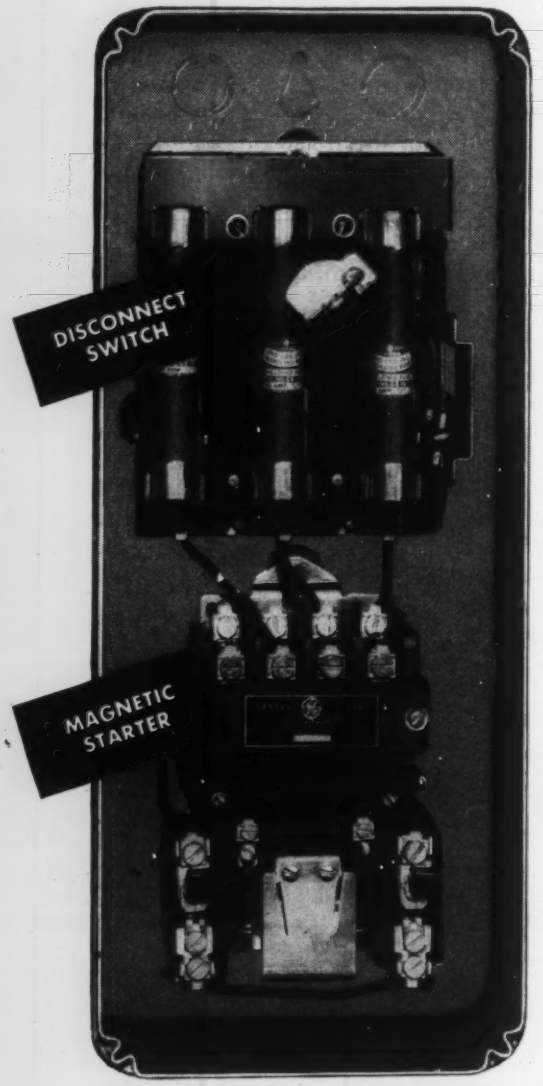
COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

Designer's

ALL YOU NEED to control and protect a motor



IN ONE COMPACT UNIT

ALL-NEW COMBINATION STARTER

All new all the way through! That's the General Electric full-voltage combination a-c motor starter, designed and built for reliable operation, easy maintenance, and long life. A compact, easy-to-mount unit, it combines contactor and its overload relays with disconnect switch and fuses. You get both motor overload *and* short-circuit protection!

Cuts installation time Starter and disconnect switch are wired together to be installed as one unit. No extra time or money need be spent on interconnections.

Saves space This one unit takes up less space than separately mounted devices. Its streamlined case means improved machine appearance.

Increases personnel safety New rotary-action disconnect switch makes it impossible to open the cover without opening the circuit. Switch handle and cover can both be padlocked to insure complete protection of personnel.

Made in NEMA sizes 0, 1, 2, and 3 for a-c motors up to 50 hp. Get the full story in Bulletin GEA-5156.

GENERAL ELECTRIC

Digest

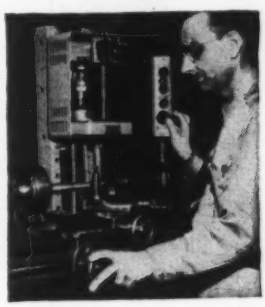
PRODUCT HIGHLIGHTS

MEASURES THROUGH THICK OR THIN!

To make sure coatings or linings on production parts are not so thin as to be insufficient, nor so thick as to be wasteful, use a General Electric thickness gage. It quickly, easily measures any non-magnetic material on magnetic iron or steel without marking the finished surface. Simply place the gage head against one side of the coated surface, and an instrument indicates the thickness. Three types available cover a range from 0.00005 to 0.750 inch. Shown is Type A, measuring copper plating thickness on electronic tube parts. See Bulletin GEC-319.

GIVES LOW-COST SPEED ADJUSTMENT!

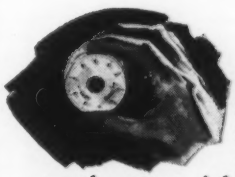
Here's the abridged edition of General Electric's Thy-mo-trol drive—the low-cost Type H1. Utilizing a simplified half-wave electronic circuit, it provides stepless speed adjustment for constant-torque loads over a 20 to 1 speed range from 1725 to 86 rpm. Where close speed regulation and full torque at low speeds are required—but not all the refinements of conventional Thy-mo-trol—the H1 offers an ideal drive at a lower price. Ratings up through ½ hp are available. See Bulletin GEA-5179.



COVERS 90 TESTING DEVICES!

Want a quick round-up of data on specialized testing and measuring devices? This comprehensive, illustrated booklet reviews more than 90 modern General Electric equipments for that purpose. Included are weights, dimensions, and prices, plus references to individual publications containing more detailed information. Convenient grouping under eleven "use" headings lets you locate specific items of interest quickly and easily. See Bulletin GEA-639.

Dial Service for Motor Speeds



Just turn the dial on this General Electric Type ACA adjustable-speed induction motor for quick speed changes, infinitely adjustable over a 3 to 1, 6 to 1, or 20 to 1 speed range. Add a 10-foot flexible cable (for the smaller motor ratings) and you can still dial your speeds. With a pilot motor instead, you can dial from *any* distance.

Compact and self-contained, the ACA is only slightly longer than a constant-speed motor of comparable rating. Standardized NEMA dimensions are used to avoid any new mounting problems. Ratings from 3 to 75 hp are available in Tri-Clad open (dripproof) construction. See Bulletin GEA-4883.

General Electric Company, Section B668-73
Apparatus Department, Schenectady 5, N. Y.
Please send me the following bulletins:

- ( ) **GEA-639—Testing and measuring equipment catalog**
- ( ) **GEA-4883—ACA adjustable-speed motors**
- ( ) **GEA-5156—Combination starters**
- ( ) **GEA-5179—Type H1 Thy-mo-trol drives**
- ( ) **GEC-319—Thickness gages**

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

Name.....

Company.....

Street.....

City..... **State**.....

yes... an oil seal that's tailor-made to *resist* corrosion

● If corrosive conditions are shortening the life of your oil seals, the Johns-Manville Clipper Seal should provide a practical solution to your problem.

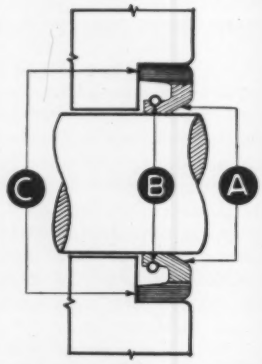
Here's why: The Clipper Seal's molded body is entirely non-metallic and is, therefore, unaffected by most forms of corrosion. To meet special conditions, the garter spring which holds the lip in contact with the shaft can be furnished in various corrosion-resistant metals . . . *or Clipper Seals of special design that do not require garter springs may be used.*

The one-piece, concentric molded design of Clipper Seals also assures a number of other advantages. The hard, tough outer heel of the Clipper Seal is resilient enough to conform even to a slightly out-of-round cavity. And the soft, pliable inner lip always maintains a light, but positive sealing pressure on the shaft, with minimum wear on the seal.

Clipper Seals are quick and easy to install, may be had in split or endless types, are available in sizes from ¼" I.D. up to 66" O.D. If you have a special sealing requirement, or wish to consult about a special design problem, write Johns-Manville, Box 290, New York 16, N. Y.

JOHNS-MANVILLE JM PRODUCTS

Here's how *Clipper Seal* works:



The flexible lip (A) is held in light but firm contact with the shaft by means of the garter spring (B). Pressure on shaft is carefully pre-determined to minimize wear, yet effectively seal against leakage. The rigid heel (C) provides a press fit in the cavity, assuring a tight lubricant-retaining seal at this point also.

Johns-Manville **PACKINGS & GASKETS**

More OEM's* Specify US Gauge Than Any Other Make!

* Original Equipment Manufacturers

. . . Because USG Assures More Value

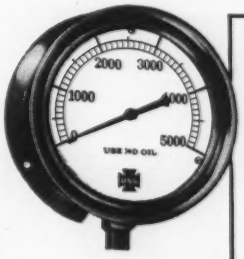
Throughout industry, the story is the same from year to year. Original equipment manufacturers (OEM's) demand substantial gauge value . . . accuracy, durability, and quality at economy prices . . . and 6 out of 10 specify US Gauges.

They know that US Instruments give more service, more accuracy, more *value* for the money. They know USG can supply all their needs—from highly specialized instruments measuring as low as 1" of mercury absolute, to standard type gauges measuring from 30" vacuum to 100,000 pounds pressure per square inch. And they know that for more than 40 years US Gauges have been the standard of dependability. So more original equipment manufacturers specify US Gauges than any other make.

Next time you order gauges, follow the lead of these satisfied users . . . buy US Gauges. For more information about US Gauge write today. United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Penna.

US GAUGES—BETTER INSIDE . . . BETTER OUTSIDE . . . BETTER ON YOUR PRODUCT

UNITED STATES GAUGE



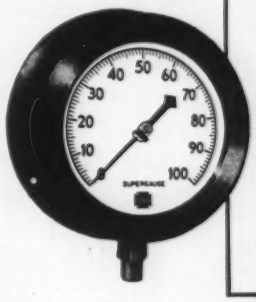
SOLID FRONT GAUGES

A complete line of large size solid front gauges for use with all gases. In these gauges a solid wall separates the bourdon tube and movement section from the dial to give maximum protection to observer. Entire back of case is fitted with a spring-mounted safety release plate which will discharge the pressure media away from observer if bourdon tube ruptures. Tubes of selected beryllium copper with threaded socket and tip connection. Deep bushed stainless steel movement. Ranges: 30 to 5,000 lbs. p.s.i.

CHEMICAL GAUGES

(Clean-out & Protected Types)

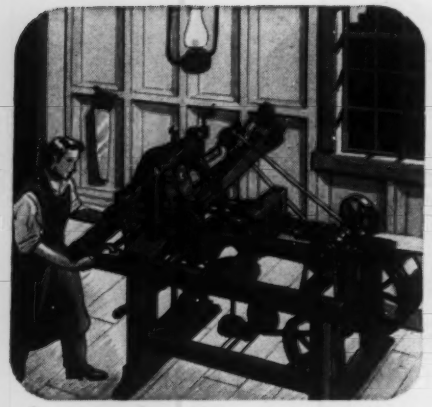
For use with any media whose viscosity may require provision for periodic cleaning of gauge. Upper housing is of alloy steel with a specially designed seat to receive the corrosion resistant diaphragm on a tapered fit, metal to metal seal. Diaphragms are available in stainless steel, aluminum, tantalum, Neoprene and in silver and other precious metals. Mounting flange supplied as standard in forged steel. Ranges: 30" vacuum to 400 lbs. p.s.i.



ELECTRIC ALARM GAUGES

Pressure actuated, high-capacity, snap-action switches with accurate repeatability and low switching differentials. For use on hydraulic pumps, presses, etc. or for use as a signaling or control mechanism for low and high tank levels or pressures. Type V is a non-indicating switch containing 2 independent, single pole, double throw switches actuated from a single bourdon tube. Type VI is identical to type V but is equipped with a second independent bourdon tube so that the indicated pressure is entirely independent of the element actuating the switches. Ranges: 0 to 30" vacuum, 15 to 20,000 lbs. p.s.i.

PRODUCTS OF UNITED STATES GAUGE... Absolute Pressure Gauges • Aircraft Instruments • Air Volume Controls • Altitude Gauges • Boiler Gauges • Chemical Gauges • Dial Thermometers • Glass Tube Thermometers • Flow Meters • Inspectors' Test Gauges • Laboratory Standard Test Gauges • Marine, Ship and Air-Brake Gauges • Recorders • Controls and Alarm Gauges • Voltmeters • Ammeters • Welding Gauges



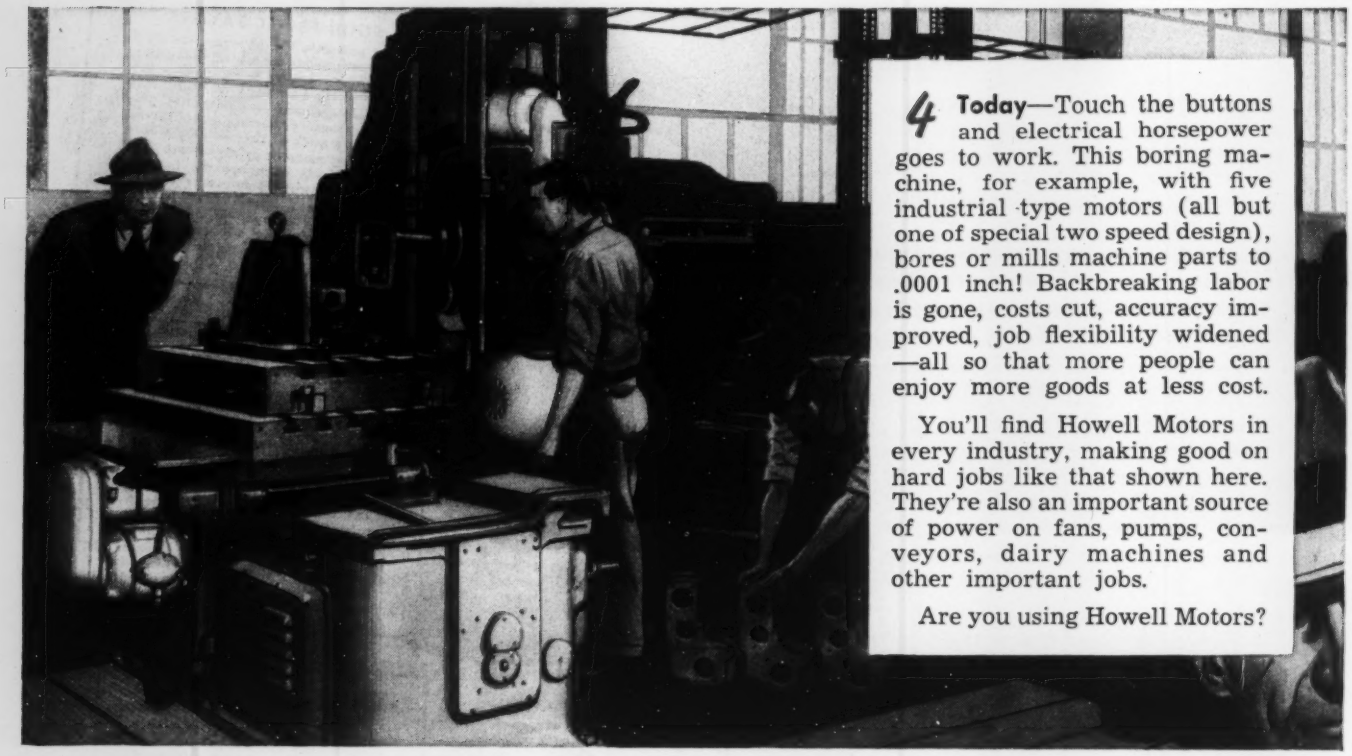
1 **1865**—Here's how machines looked before man applied electricity for industrial usage. Gear setups were crude. Making parts fit was a matter of luck and plenty of tinkering by operators.

2 **1907**—Electrical horsepower gave production a big boost. But gear mechanisms were far too cumbersome. Repairs were frequent. Men were still struggling to make one motor do the work of many . . .

3 **1915**—Howell "Red Band" Electric Motors arrived. These rugged, industrial type motors were specially designed to withstand hard usage. Soon, Howell Motors appeared in this and other industries.

NOW, IT'S TOUCH AND GO!

(and parts are machined quicker and to closer tolerances)



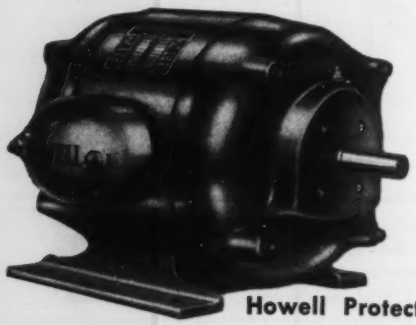
4 **Today**—Touch the buttons and electrical horsepower goes to work. This boring machine, for example, with five industrial type motors (all but one of special two speed design), bores or mills machine parts to .0001 inch! Backbreaking labor is gone, costs cut, accuracy improved, job flexibility widened—all so that more people can enjoy more goods at less cost.

You'll find Howell Motors in every industry, making good on hard jobs like that shown here. They're also an important source of power on fans, pumps, conveyors, dairy machines and other important jobs.

Are you using Howell Motors?

Free enterprise encourages mass production, supplies more jobs—provides more goods for more people at less cost.

Here's another precision-built Howell Motor . . . industrial type with copper or bronze bar rotors . . . specially insulated . . . statically and dynamically balanced.

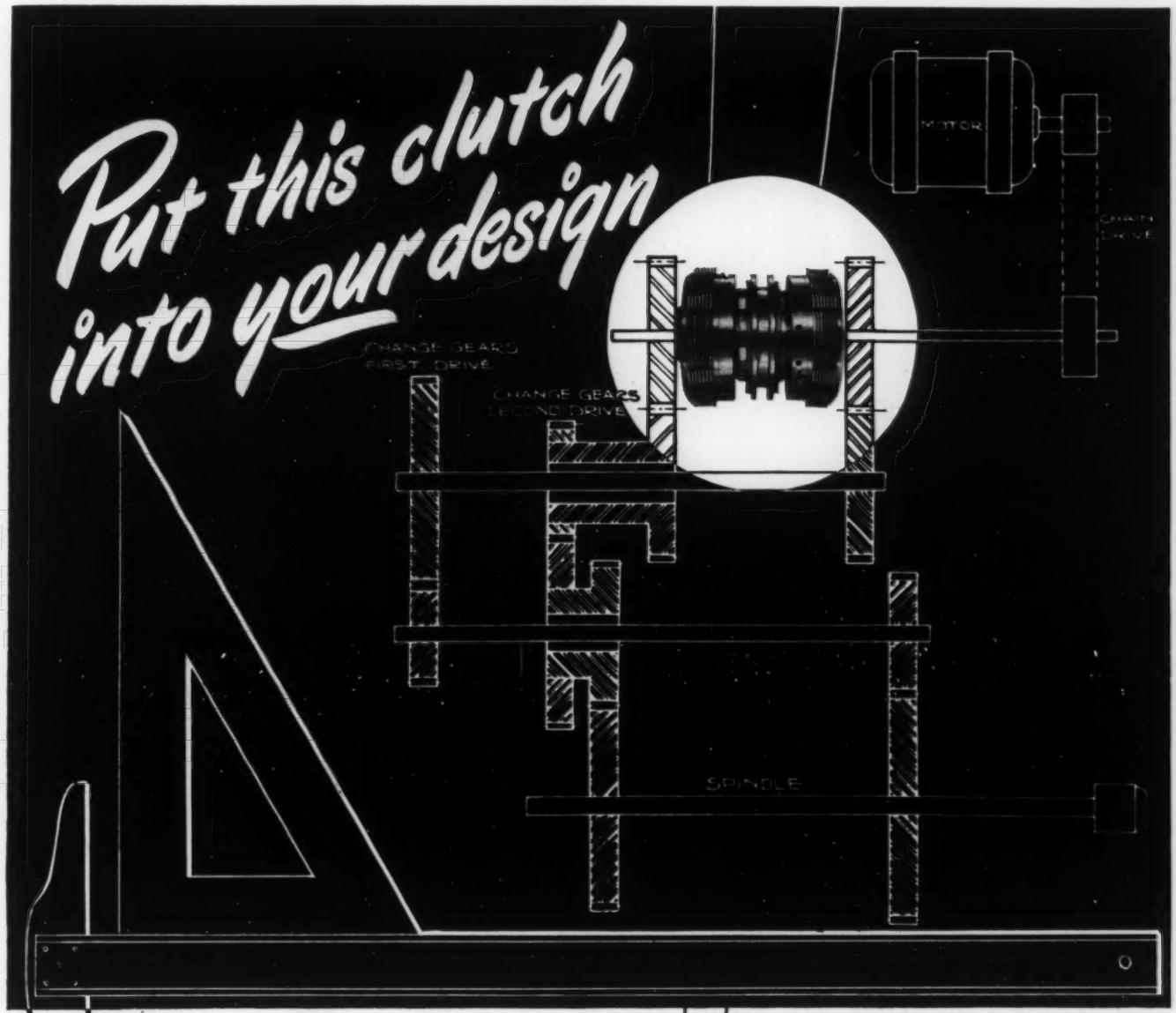


Howell Protected Type Motor

HOWELL MOTORS

HOWELL ELECTRIC MOTORS CO., HOWELL, MICH.

Manufacturers of Quality Industrial Type Motors Since 1915



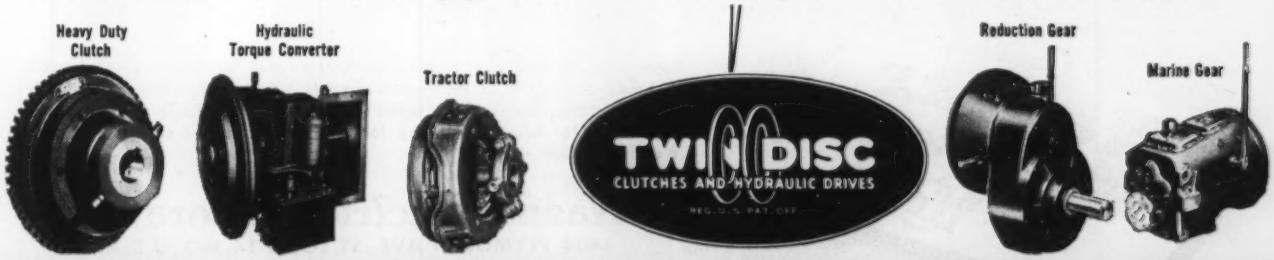
Twin Disc Machine Tool Clutches are engineered to fit easily into your design. They can be used as primary or cut-off clutches or as clutches that control a given function during continued operation . . . such as change-of-speed clutches where frequent operation is required.

These compact Twin Disc Clutches have exceptionally high torque capacity compared with the relatively small space required for installation. For example, a 5.5″ Twin Disc Oil-type MTS Clutch with seven driving plates has a working torque capacity of 3200 inch-pounds.

This high torque capacity is obtained through use of materials with high friction coefficient . . . ample number of friction surfaces . . . a quick and easy method of removing oil from between the friction surfaces.

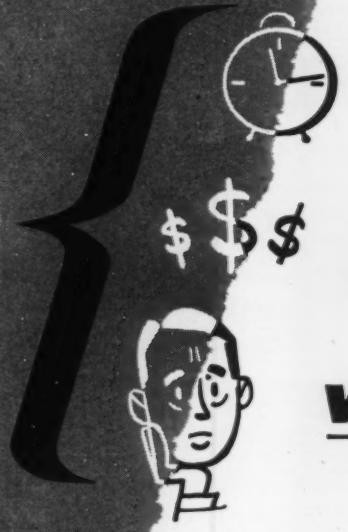
Twin Disc builds both oil and dry type Machine Tool Clutches . . . single and duplex construction . . . sizes from 3″ to 12″. For complete information write for Bulletin 134-A.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).



SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

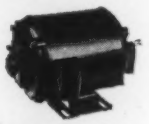
you'll save { time / money / worry



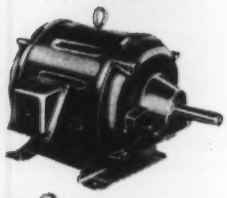
when you standardize on Wagner motors

because of:

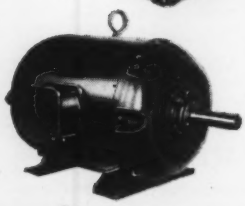
- Immediate Availability on Many Types and Sizes.
- Improved Engineering Features that Assure Long Life and Efficient Operation.
- A Liberal Warranty.
- A Wide Variety of Types and Sizes.
- Nationwide Service Facilities with Replacement Motors and Parts—*When You Need Them —Where You Need Them.*



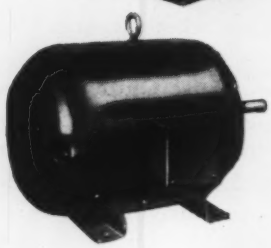
Repulsion Start Induction Motor ¼ to 15 h p.



Open-type, Polyphase Squirrel Cage Motor ¼ to 400 h p.



Explosion-Proof Motor ½ to 200 h p.



Totally-enclosed, Fan-cooled Motor 1½ to 200 h p.

Wagner Electric Corporation EST. WE 1891

Regardless of what your motor requirements may be, Wagner can furnish a standard motor to fit your needs. Twenty-nine branch offices, located in principal cities, are ready to assist you whenever you have a motor problem. Write for Bulletin MU-185 for information on the complete line of Wagner Motors.

Wagner Electric Corporation
6404 PLYMOUTH AVE., ST. LOUIS 14, MO., U.S.A.

Consult Wagner Engineers on all Electric Motor Problems

M49-11

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE PRODUCTS

As the white outline indicates, a standard unit of much greater frame size would be required to do the work of Speedaire.
The unit operates a Ruggles-Coles Dryer, built by the Hardinge Co., Inc., York, Pa.

SPEEDAIRE ... for 3 years 24 hours a day

THREE years ago, a South Carolina kaolin plant installed one of Cleveland's new fan-cooled Speedaire worm gear speed reducers to drive a rotary kiln. It has operated almost continuously, day and night, ever since, with unimpaired efficiency in spite of the heat and dust.

As the photograph indicates, a limited area was available to install a speed reducer, but it was entirely adequate for Speedaire, because it occupies 42% less space than a conventional worm gear drive of comparable capacity. Speedaire also saved $128.50 on initial cost.

Because Speedaire is fan-cooled, it will do more work—will deliver up to *double the horsepower* of standard worm units of equal frame size, at usual motor speeds. It can be installed economically on many applications where other types have been used heretofore—giving you the advantage of a compact right-angle drive. Speedaire gives the same long, trouble-free service characteristic of all Clevelands.

For full description, send for Catalog 300. The Cleveland Worm & Gear Co., 3265 East 80th St., Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication.
In Canada: Peacock Brothers, Limited.

CLEVELAND
Worm & Gear
Speed Reducers

ZERO SLIPPAGE!

. . . that's why sensational

Gilmer "TIMING" BELTS

(PATENT APPLIED FOR)

widen the whole field of belt application

Now positively synchronized belt drive is a reality! It's achieved by flat, endless Gilmer "Timing" Belts with teeth engaging axial-grooved pulleys. That's the end of slip, creep and speed variation —anywhere from inches per minute to 10,000 fpm—anywhere from 1/20 hp drives to 500 hp.

Fixed, non-adjustable centers are made possible because there is no stretch problem with Gilmer "Timing" Belts. They combine positive engagement with the extreme tensile strength, flexibility and weight-saving of Neoprene-bedded steel cables. That points to new space economy in laying out high speed drives employing small pulleys.

No other belt offers so many possibilities for modernizing difficult power applications. No other belt makes long life and precision so certain where true synchronization is a must. This has been proved under the toughest, most diversified conditions. The Gilmer "Timing" Belt may lead to startling improvements and economies in machines you are now designing. You can have the help of Gilmer Engineers. Write for full particulars.

Gilmer has the PULL

Gilmer BELTS

L. H. GILMER COMPANY

Tacony, Philadelphia 35, Pa.

DIVISION OF UNITED STATES RUBBER COMPANY

GILMER V-BELTS with a "Great Gang" of features. (1) Tough resilient Top Tension Section. (2) Firm-bonded Rayon Pulling Cords, locked against rub, extend good service life. (3) Firm cushion section keeps cool at full-load speed. (4) Sturdy Jackets defy oil, dirt and wear. (5) Lengths matched at operating tension are maintained by Stretch-Control characteristics.

GILMER FHP V-BELTS for small-sheave single belt work show equal high development. Stretch is worked out of Gilmer "Normalized" cords to leave them alive! Count on lasting tension—cool, smooth running—no worry. Standard lengths to 100" outside. Non-standard lengths and sections from the large assortment of Gilmer moulds. All Gilmer V-Belts show that—in belts—"Gilmer has the PULL."

GILMER SPEEDAGE-KORD BELTS

A flat, endless belt noted for smooth running and record long life on grinders and similar drives to 50,000 rpm. The high-strength cord is bonded to stay put. No plies to separate. No splices to come apart. Light, medium and heavy construction in both Standard and Super-Service Nylon types.

GILMER RH FLAT BELTS

Strong, endless pulling cords are securely locked in position to guard against ply separation and insure cool running. The high tensile strength, low stretch and extreme flexibility of this thin-section endless belt make it right for small pulleys and comparatively heavy loads, at speeds to 7400 fpm.

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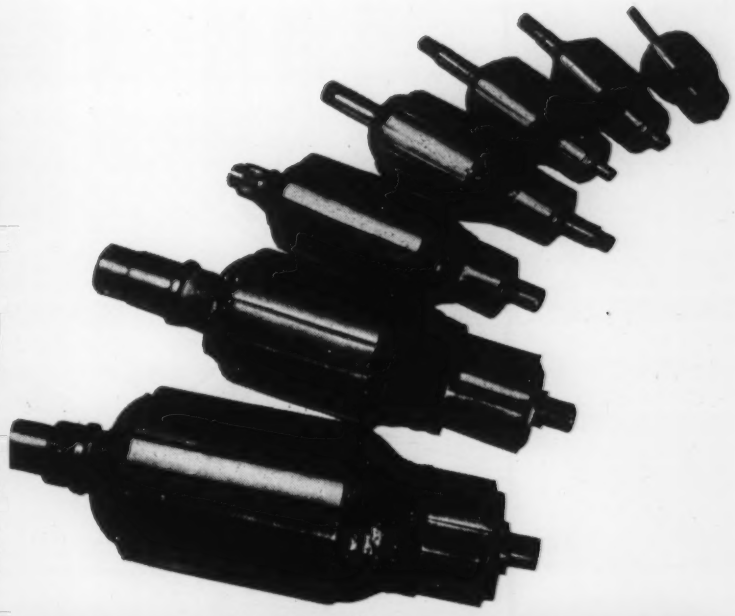
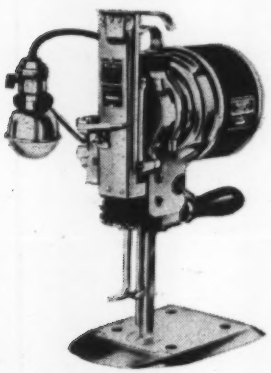
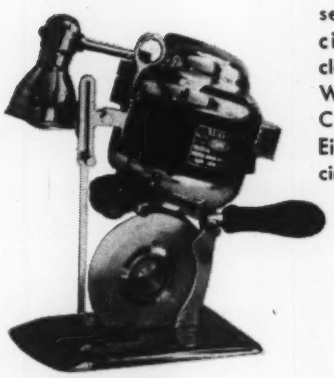
Here's How to Improve Your Motorized Products!





Maimin Super Automatic XXX self-sharpening, straight-knife cloth cutter. H. Maimin Co., Inc., 575 Eighth Ave., New York.



Wolf Type "M" self-sharpening, circular-knife cloth cutter. The Wolf Machine Co., 308 E. Eighth St., Cincinnati.

GET THIS *Free Book!*

Robbins & Myers matched motor parts help you design equipment with qualities your customers want. Smooth appearance, light weight, compact power, flexibility—features that *sell* your products. For R & M motor parts trim bulk—improve looks—give top performance on the job. And R & M types are interchangeable to step up and simplify your production.

TAKE CLOTH CUTTERS, FOR INSTANCE

When leading producers of specialized cloth cutters called on Robbins & Myers to design and supply their motor parts, dynamic inertia was reduced, vibration was eliminated—and the equipment now runs cooler. As a result, clothing makers can keep production at top speed . . . with accuracy and efficiency at a high level . . . and with a minimum of worker fatigue.

HERE'S HELP FOR DESIGNERS

If you're dreaming up new products or modernizing current designs, it will pay you to learn about R & M matched motor parts. Our free 32-page reference book gives design, application, and performance data on the complete line. Write for it today—just ask for Book No. M-1871D.

ROBBINS & MYERS · INC. MOTOR DIVISION
Springfield 99, Ohio • Brantford, Ontario

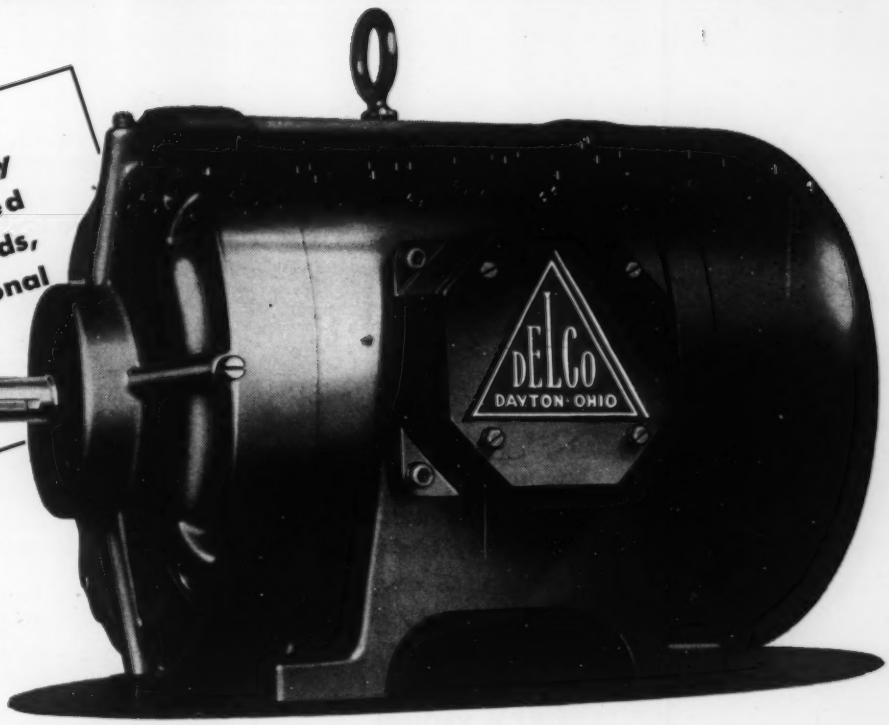
MOTORS · HOISTS · CRANES · FANS · MOTOR PARTS · FOUNDED 1878

MRC
the M-R-C
"Synthe-Seal" bearing
A standard-dimension ball bearing with a removable synthetic rubber seal impervious to oils and greases
MARLIN-ROCKWELL CORPORATION
Jamestown, New York

DELCO MOTORS

STAND UP TO THE JOB

There is a Delco totally enclosed fan-cooled motor to fit your needs, in sizes from fractional ratings to 75 h.p.



Here at the factory, Delco motors are rated in terms of horsepower. In the field of industry, we are proud to say, they are rated *tops.* Large or small, every Delco motor is built to carry its rated load and to keep on carrying it even under the most adverse conditions. When you count on Delco motors for power, you don't have to count on down-time.

Delco's ability to deliver continuous, trouble-free power is due to special construction and design features—such as positioned bearings, Delcote coil insulation, corrosive-resistant cast iron frame, positive lubrication, dynamically balanced rotor and shaft assembly, water-tight conduit box.

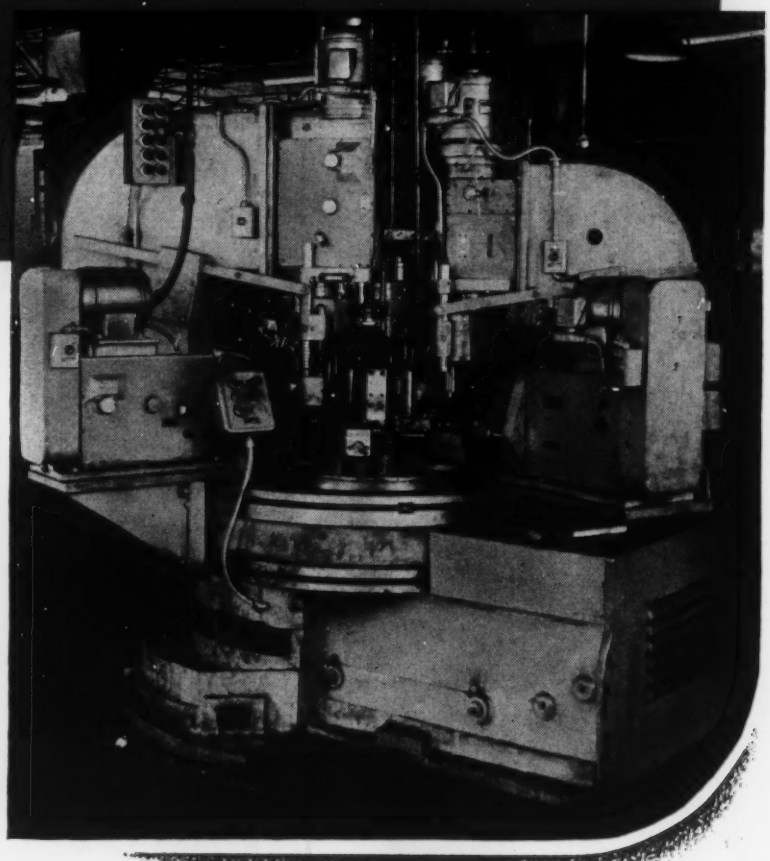
For complete data on Delco Motors, address Delco Products, Dayton, Ohio, or our nearest sales office.

DELCO MOTORS

DELCO PRODUCTS, DIVISION OF GENERAL MOTORS CORPORATION

SALES OFFICES: CHICAGO • CINCINNATI • CLEVELAND • DETROIT • HARTFORD, CONN.

From Century's Complete Line It Was Easy to Select 7 DIFFERENT Century MOTORS to Drive This Automatic Drill Press



The automatic drill press shown here is equipped with the following standard Century motors:

1 — one horsepower 1735 RPM horizontal motor on a cross feed

1 — one horsepower 1735 RPM vertical motor on a vertical feed

2 — one horsepower 1155 RPM horizontal motors on cross feeds

1 — one and one-half HP 1155 RPM horizontal motor on cross feed

1 — one horsepower 3500 RPM vertical motor on vertical feed

1 — two HP 1740 RPM vertical motor on vertical feed

1 — two HP 1155 RPM horizontal motor rotating the circular table

The correct Century motor for your job supplies the *right* amount of power and starting torque at the right speed combined with the *right* frame mounting and right protection from surrounding atmospheres.

Century's wide range of types and kinds of electric motors in sizes from 1/6 to 400 horsepower can simplify complicated electric power problems.

Specify Century motors for all of your electric power requirements.

Popular types and standard ratings are generally available from factory and branch office stocks.

CENTURY ELECTRIC COMPANY
1806 Pine St. • Saint Louis 3, Missouri

-600

OFFICES AND STOCK POINTS IN PRINCIPAL CITIES

a new *Merchandising Plan*

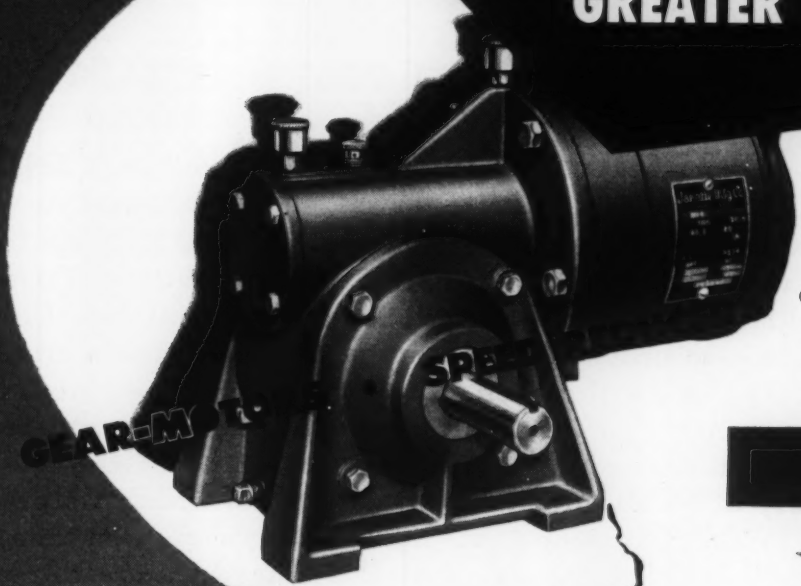
to give you

LOWER COSTS

BETTER PRODUCT DESIGN

IMPROVED PLANT OPERATION

GREATER PRODUCT SALES APPEAL



• ROTARY CONVERTERS

"the right speed, the right power"

Janette's new merchandising plan can help *you* improve your product design or modernize your plant operation . . . *at lower cost!* Write today for Bulletin 5000 for information about this radically new plan.

Janette

MANUFACTURING COMPANY

556 West Monroe Street

Chicago 6, Illinois

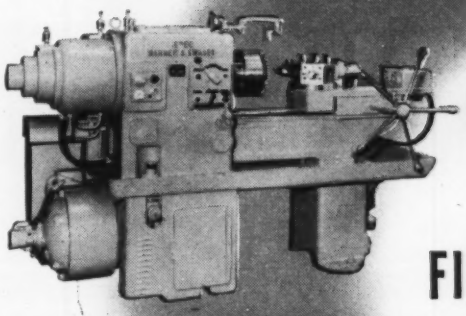
Facilities you can use *Profitably in Buying* Medium *and* Small Castings

NE is the well known and long established symbol for quality carbon and alloy steel castings and gears used by industry. Diversified facilities at National Erie Corporation also provide a wide range of medium and small steel castings produced on squeezer and roll-over moulding machines . . . Our Rotoblast equipment illustrated here facilitates economical, speedy cleaning of the wide diversity of small and medium cast parts which we produce for a multitude of light industrial machines. National Erie engineers, metallurgists and craftsmen control every operation from raw materials to finished product within our own plant. We can serve you as we are serving hundreds of others with these complete and diversified facilities. Bulletin No. 7 fully describes our capabilities. Write for it.

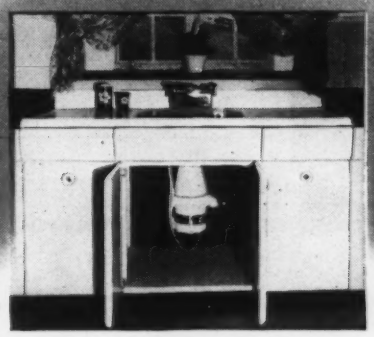
NATIONAL ERIE CORPORATION

ERIE, PENNSYLVANIA • U. S. A.

One important thing in common



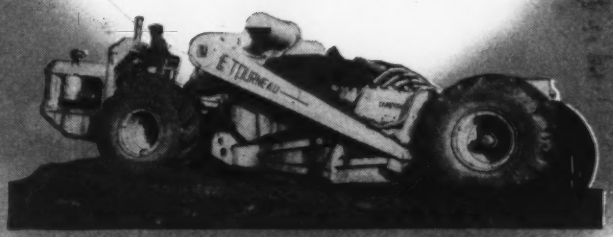
A *FIBERGLAS*-insulated main drive motor on this "Electro-Cycle" turret lathe permits increased reversal capacity not possible with organic insulating materials. Product of: Warner & Swasey, Cleveland, Ohio.



A *FIBERGLAS*-insulated motor in the "EUREKA Dispos-O-Matic" helps provide housewives with a dependable, time-saving waste food disposer. Product of: Eureka Williams Corporation, Bloomington, Ill.

A FIBERGLAS*-INSULATED ELECTRIC MOTOR

A *FIBERGLAS*-insulated motor in this "Precise 40" hand tool makes it possible to increase power from 1/7 HP to 1/5 HP without increasing the size of the motor frame. Product of: Precise Products Company, Racine, Wisconsin.



FIBERGLAS-insulated motor on the "LeTourneau Tournapull" loads, steers, turns and empties these giant earth movers. Motor dependability is important because they're operated under the toughest weather conditions. Product of: R. G. LeTourneau Inc., Peoria, Ill.

Foremost designers and engineers are finding that Fiberglas-base Electrical Insulating Materials help solve problems of motor size and weight . . . are specifying them to provide performance insurance against the damaging effects of heat, dust, vapors and most corrosive acids, and many other causes of motor failure. Even where electrical equipment is not called upon to perform under adverse conditions, they have found it's good insurance to have the added protection of insulations having this inorganic-base material.

Write Owens-Corning Fiberglas Corporation, Dept. 808, Toledo 1, Ohio, today for a copy of the "Fiberglas Electrical Insulating Materials" manual. Branches in principal cities.

In Canada: Fiberglas Canada Ltd., Toronto, Ontario

*Fiberglas is the trade-mark (Reg. U. S. Pat. Off.) of Owens-Corning Fiberglas Corporation for a variety of products made of or with glass fibers.

OWENS-CORNING FIBERGLAS

ELECTRICAL INSULATING MATERIALS

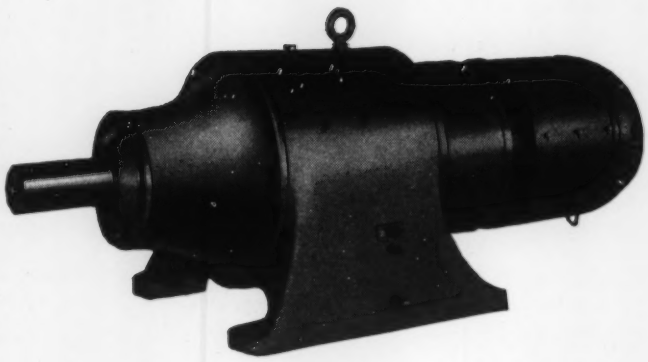
Established 1888

D.O.James

GEAR SPEED REDUCERS

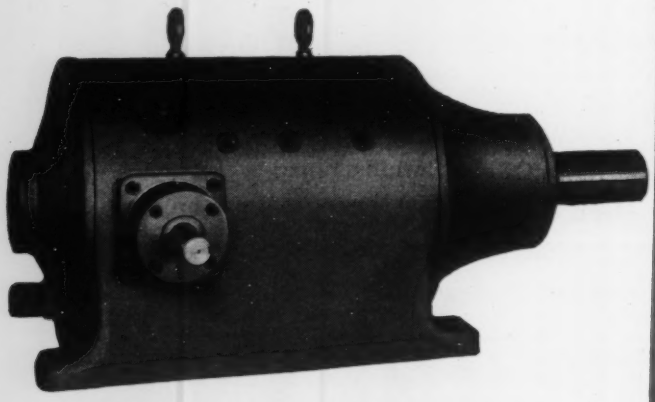
STRAIGHT LINE GEAR REDUCER

35 Sizes • Ratios of 10:1 to 1200:1
3/4 to 75 HP.



MOTORIZED GEAR REDUCERS

35 Sizes • Ratios of 10:1 to 1200:1
3/4 to 75 HP. • Horizontal or Vertical



RIGHT ANGLE GEAR REDUCER

33 Sizes • Ratios 8:1 to 1100:1
1/2 to 75HP. • Horizontal or Vertical

Power As You Want It!

Whether your power transmission problem is straight-in-line, around the corner or can be done with a motorized job—these D. O. James Gear Speed Reducers will really handle it. They are highly efficient, compact, quiet in operation and of great emergency strength. They are available in many sizes, wide ratio range and from 3/4 to 75 horsepower.

D.O.JAMES
GEAR MANUFACTURING CO.
1140 W. MONROE STREET • CHICAGO, ILL.

MAKERS OF ALL TYPES OF GEARS AND GEAR SPEED REDUCERS

ATLAS STEPS AHEAD

WITH NEW IMPROVEMENT IN ROLLER CHAIN

RING-FASTENED FOR GREATER SAFETY... LONGER LIFE... LESS MAINTENANCE

Here is Atlas Detachable Roller Chain with a new type of fastener less apt to be bent, sheared off, or dislodged entirely. Having no dangerously exposed points, it eliminates the possibility of a workman being pulled into a machine by the fastener catching onto his clothing.

The new type of fastener consists of three internal, equally-spaced teeth which are sprung radially into a groove on the pin. The mathematically predetermined, equal spacing of these teeth, and spring action of the connecting links, assure that the ring will maintain a tight groove tension at all times. Consequently, when struck by a direct blow, it merely turns in its groove hugging it tightly.

Disassembly can be accomplished whenever necessary with an ordinary screwdriver. The recesses between the teeth are resilient enough to provide spreading any number of times without giving the ring a permanent set.

Combined with the performance-proved qualities of Atlas Roller Chain, this new fastener offers greater safety, longer wear, and less maintenance for roller chain drives wherever they are used. For full details—write or phone Atlas today. Ask for our new catalog, "Atlas Roller Chain."

ATLAS

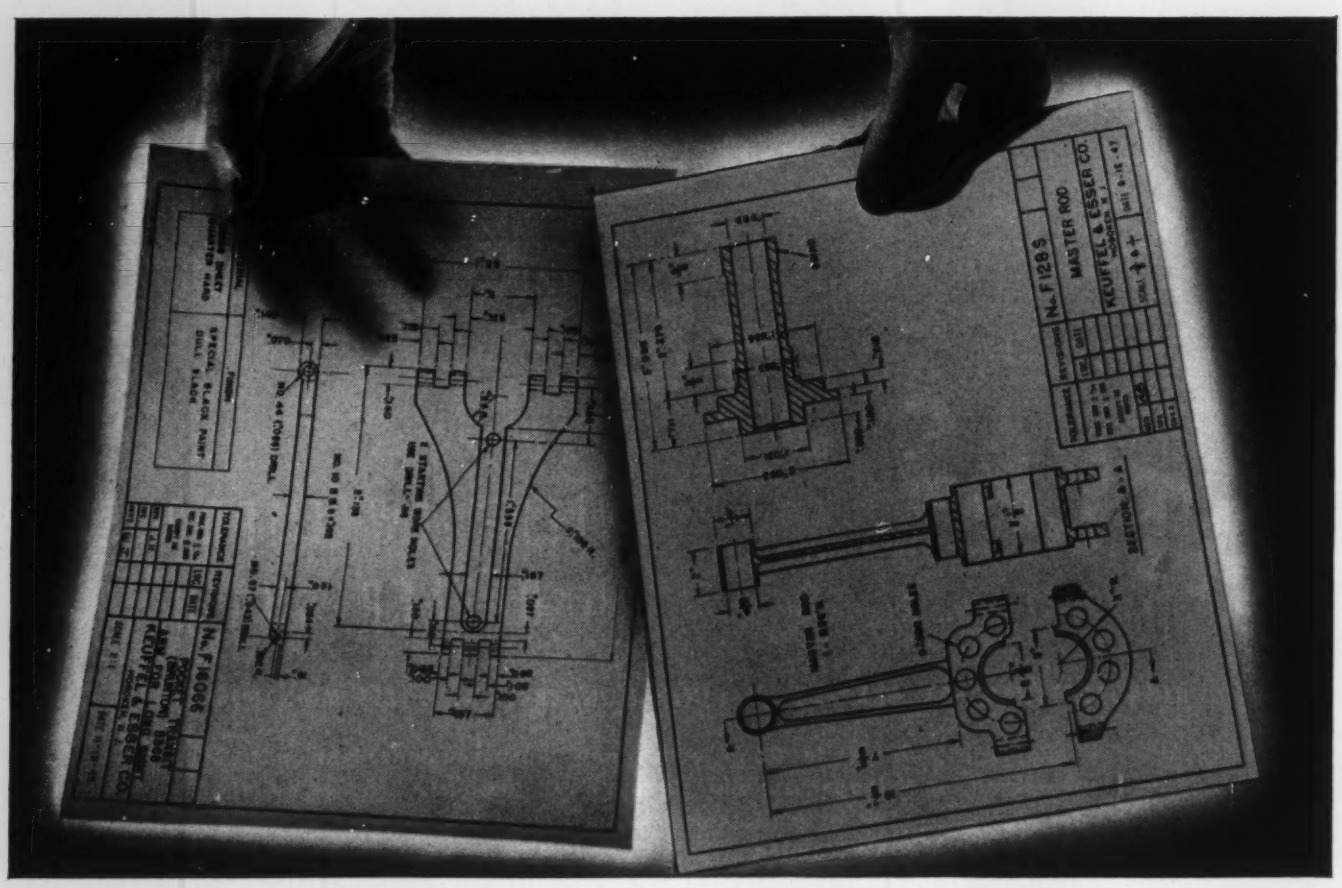
ATLAS CHAIN AND MANUFACTURING CO.

Kensington and Castor Avenues - Philadelphia 24, Pa.

K+E

partners

For 82 years K&E equipment and materials have been



ONLY HELIOS* DRY DEVELOPING MATERIALS GIVE YOU:

K&E QUALITY. Trusted by draftsmen and engineers for 82 years.

K&E DEPENDABILITY. Your best assurance of consistent results in making positive line prints.

Only when you use dependable materials can you get consistent results in making positive line prints.

To be sure of absolute K&E standards in the color-forming components required for these dry diazo products, we established a new plant where we manufacture HELIOS materials exclusively. We not only control and make the finished materials, but actually manufacture, from the raw materials, the image-forming chemical components as well. Thus HELIOS papers, cloths and films are the product of 82 years of K&E experience and K&E insistence on quality first.

HELIOS dry developed materials cover a wide field of reproduction needs. They consist of opaque papers (black, blue and maroon line) and opaque cloth for working prints, besides transparent papers and cloth and clear and matte films, for intermediate originals (to use instead of originals).

For samples and full information about the HELIOS line and what it can do for you, ask any K&E Dealer or Branch or write us here in Hoboken, N. J.

PARAGON* DRAFTING MACHINES TAKE WASTE MOTION OUT OF DRAWING

The PARAGON Drafting Machine combines T-Square, triangles, protractor and scales, all in one single unit, controlled entirely by one hand. The scales glide into any position on the board. The lightest touch rotates them to the angle desired. You can draw all lines to exact length.

The design of the PARAGON Drafting Machine assures permanent accuracy. The open center arm construction makes it practically impossible to disturb the band tension, which is properly set at the factory and needs no further adjustment.

Let your K&E Dealer or Branch demonstrate this machine or write for full description to Keuffel & Esser Co., Hoboken, N. J.

LEROY* LETTERING AND SYMBOL DRAWING IS UNIFORM AND QUICK

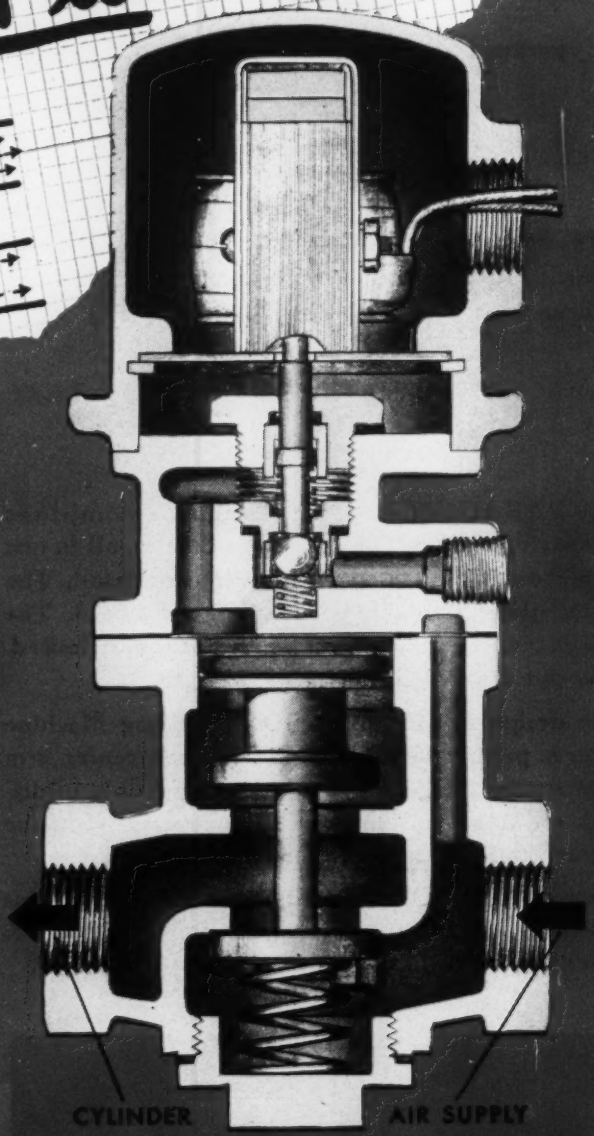
LEROY lettering and symbol drawing need no special skill or training. LEROY equipment offers a wide variety of alphabets and sizes, including Regular Gothic, Reversed, Condensed, Extended and Outline Gothic, Cheltenham, Greek, Isometric alphabets and ellipses, Electrical, Map and Welding symbols.

K&E can make special LEROY templates with your own words, phrases, designs, symbols or trade marks.

Ask your K&E Dealer or any K&E Branch for a demonstration or write to K&E, Hoboken, N. J. for the LEROY Booklet.

*Trade Mark®

Install Ross-In-Line for a Full-Flo Line!



Full Pipeline Capacity

with lower initial and operation costs...

Yes, these new Ross-In-Line valves fill the bill—a dozen ways in every plant. Solve your "on-and-off" problems. Instant shut-off for plant-wide systems—a single coolant line — or split second control of a single acting cylinder. These air-controlled valves handle pressures 0 to 125 p.s.i.—*air, liquid,* and *gas.* Do it *better,* too, yet at lower cost.

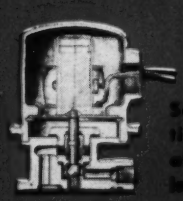
Here's Why...

● FULL LINE CAPACITY . . . Full Flo design provides *full* pipe size opening throughout valve. Eliminates "pinching" of line, reduces friction loss.

● LOWER FIRST COST . . . More capacity—therefore more efficiency—per dollar. Quick, easy, straight line installation. No mounting brackets.

● LOWER OPERATING COST . . . Only four moving parts, all non-corroding. Inspection without removing from line. Solenoid consumes only .2 amps. holding and 1.2 inrush at 110 v. 60 cy. Interchangeable pilot section simplifies service, decreases inventory.

Designed and built to *stand up,* seals are Hycar, other parts naval brass and stainless steel. Created specifically for efficient air operated control, straightway and 3-way, normally open or closed, ¼" to ¾" FULL FLO pipe capacity. As a dependable answer to your valve problems, Ross offers this latest addition to a line of over 500 quality valves designed for every phase of air control. Write for details and name of Ross representative in your area.



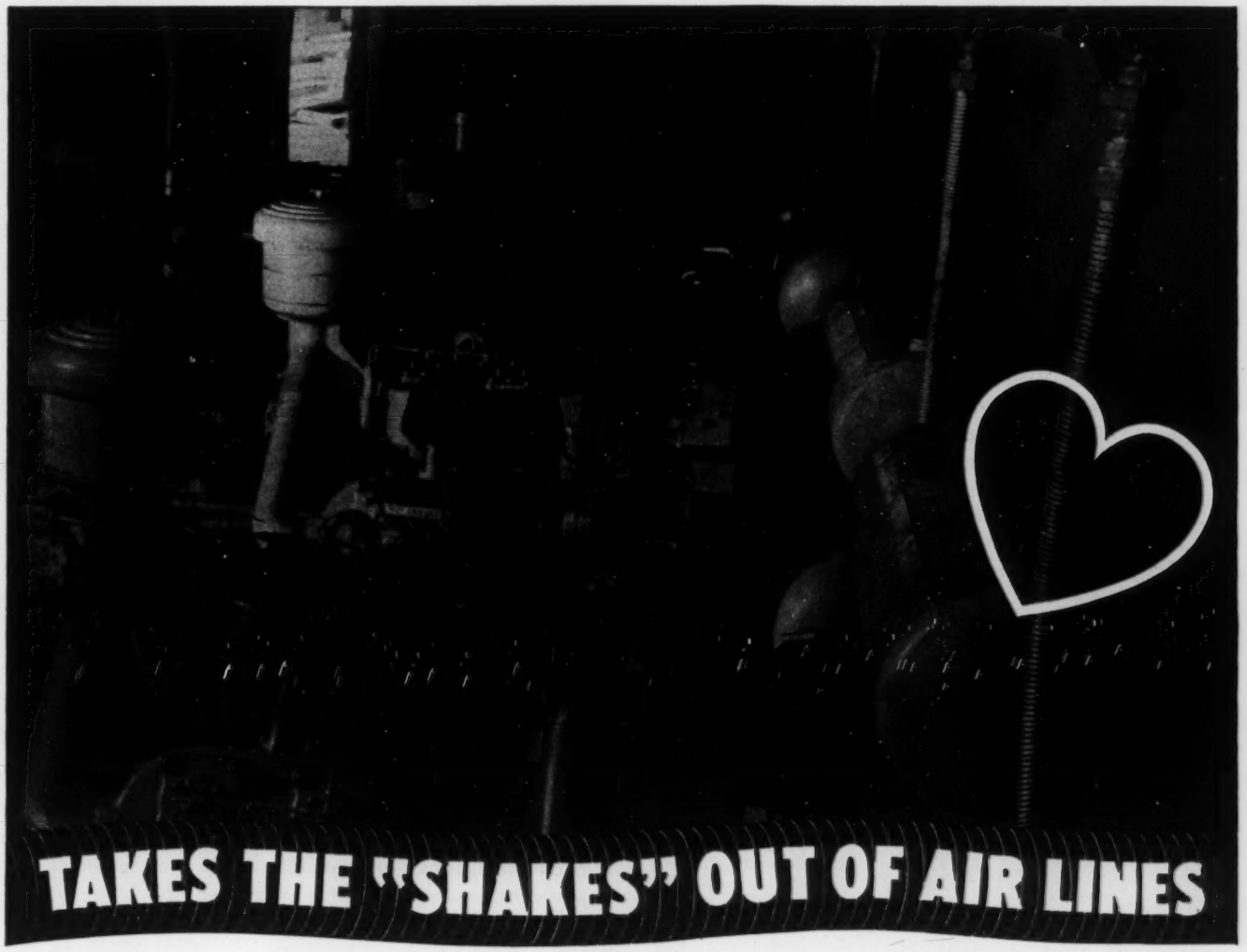
Solenoid-Pilot Sections Interchangeable on all 16 Ross-In-Line Bodies.

ROSS OPERATING VALVES

120 E. Golden Gate Avenue, Dept. 138 • Detroit 3, Michigan

ROSS

THE BRIDLE FOR AIR HORSEPOWER



TAKES THE "SHAKES" OUT OF AIR LINES

Penflex Flexible Metallic Hose prevents vibrations on compressed air lines, easily... safely... economically

With a mighty roar, 15 diesel-powered air compressors pump a steady air supply for air tools and equipment used on a world-known project. During the installation of these powerful compressor units, a method was required to prevent constant vibration from being transmitted to the rigid air lines.

That's where Penflex "Flexineering" service paid off. By using 3" Penflex interlocked flexible metal hose as connectors between compressors and pipe lines, the "shakes" are eliminated. Tight as a pipe, but flexible, Penflex hose "soaks up" constant vibration, assuring smooth air power . . . leak-proof, low-cost service. Penflex hose is also used to carry off obnoxious diesel exhaust, preventing dangerous leaks and vibration.

When your plant is troubled with flexible tubing problems, whether they pertain to production, maintenance or high operating costs, let Penflex "Flexineering" find the right answer. As America's oldest manufacturer of flexible hose, Penflex offers helpful layout-design service on flexible tubing applications to all industries. For flexible metallic hose, tubing, or couplings from 1/8" I.D. and up . . . for handy, time-saving automatic barrel fillers and pneumatic rivet passers . . . for the finest in engineering service, call on Penflex. Write today, to . . .

PENNSYLVANIA FLEXIBLE METALLIC TUBING CO.
7239 Powers Lane **Philadelphia 42, Pa.**

Branch Sales Offices—BOSTON • NEW YORK • CLEVELAND • CHICAGO • HOUSTON • LOS ANGELES

Penflex... HEART OF INDUSTRY'S LIFE LINES

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Topics

PRONE-POSITION pilot bed designed by the Aero-Medical laboratory of Air Materiel Command reduces the possibility of pilot "blackout" and requires less space for the cockpit, permitting the development of aircraft with slimmer silhouettes and less drag. Special controls use two movable pans with adjustable handgrips to act as levers and provide a restful position for the pilot's arms.

METALS such as lead and tin, ordinarily poor conductors of electricity, become superconductors at the temperature of liquid helium, completely losing their electrical resistance. Resistance reappears when a large electric current is passed through the superconductor or when a sufficiently strong magnetic field is applied.

WORLD'S LARGEST proved reserve of aluminum ore of present economic significance has been discovered on the islands of Jamaica, Haiti and Hispaniola in the Caribbean. The reserves sampled to date total at least 350,000,000 tons of which 90 per cent is in Jamaica.

LIGHT-SENSITIVE CELLS for measuring the intensity of lighting have been developed which are accurate within 10 per cent for any color of light or angle of light incidence. Developed by General Electric, the cells are laminated, consisting of lenses and filters cemented to the cells themselves.

FIRE-RETARDANT paint for coating wood has been developed to withstand a 2000 F blowtorch test for 30 minutes without any flame spread. Known as Flame-Seal and developed by the Stallton Chemical Corp., the coating undergoes a physical transformation when exposed to fire. It immediately forms a white crust which creates a hard protective wall at least eight times the thickness of the original coating.

LEATHER treated with synthetic resins has greatly improved wear resistance. The process, developed at the National Bureau of Standards, should reduce the amount of tanning materials now required to produce high-quality leather. Abrasion resistance of sole leather is improved approximately 75 per cent for vegetable-tanned crust leather impregnated with n-butyl methacrylate monomer, followed by polymerization.

CONVERTAPLANE, first cousin to the helicopter, which incorporates variations between the operational characteristics of the fixed-wing airplane and those of the helicopter is under development. The ultimate design, according to R. H. Prewitt, president of Prewitt Aircraft Co., may involve a rotating wing device to lower a plane to safety or a high-performance machine which is, at choice, airplane or helicopter.

TUNGSTEN POWDERS with precise and predictable particle size and distribution are being produced by Sylvania Electric Products Inc. For producing tungsten carbide, these commercial powders contain individual particles of which 75 per cent measure below five microns.

DEPTH HARDENING of mild steels may be accomplished in a matter of a few minutes with a compound called Hi-Speed-It, manufactured by Wilson Carbon Co. Inc. No toxic fumes are produced in the process involving heating, dipping in the compound, reheating, and quenching.

VITREOUS ENAMELS have been developed by the duPont Co. for application to aluminum alloys. Produced on a limited basis, the special enamels are suited for 43 alloy or wrought 61S alloy and are resistant to mild acids.

COLD-FINISHED carbon steel, heat treated by induction equipment and known as Electreat, may be machined or ground and is available in plain carbon, free cutting, and alloy grades up to 0.5 carbon.

RUBBER consumption per capita in the United States is 17 pounds per year. For the balance of the world it is 0.9-pound, while Canada, England and Russia consume 11, 8 and 1½ pounds, respectively.

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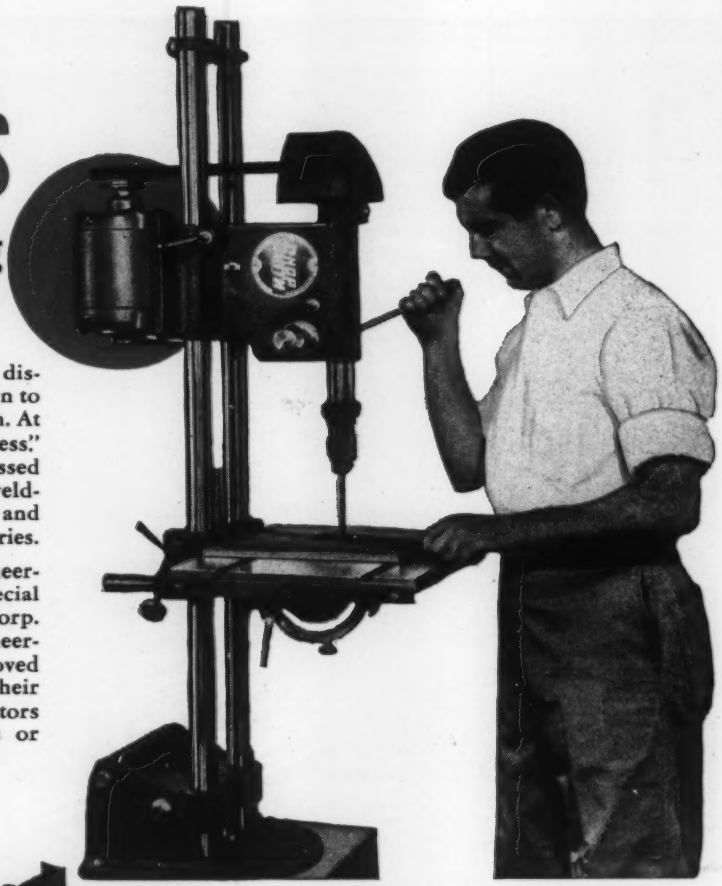
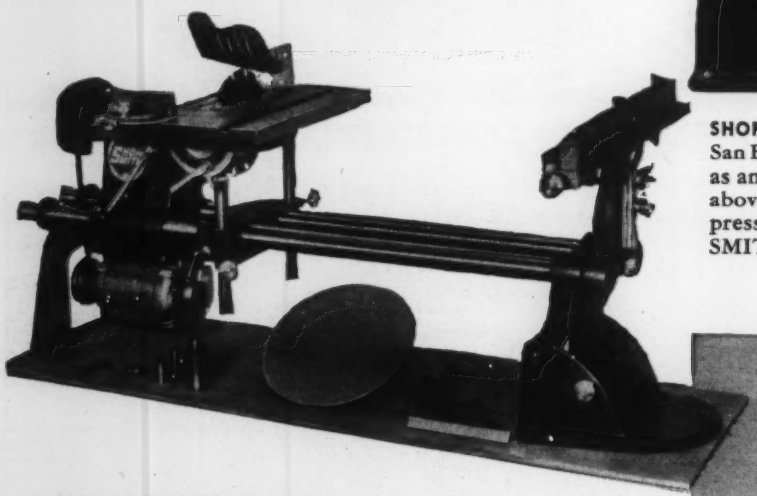
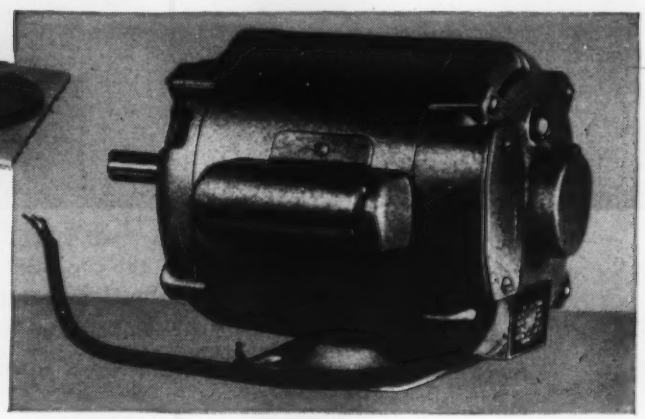
Typical of the problems A. O. Smith has solved in engineering electric motors to fit product requirements is the special "Shopsmith" design developed for Magna Engineering Corp. A. O. Smith also extends its complete research and engineering facilities to other manufacturers seeking improved performance or requiring unusual characteristics in their component power equipment. SMITHway Electric Motors can be built either to your particular specifications or furnished in a full range of standard sizes.





SHOPSMITH, product of Magna Engineering Corp., San Francisco, is a 5-in-1 shop tool that can be used (left) as an 8″ saw, 12″ disc sander, 34″ lathe, and (as shown above) a 15″ vertical drill press and as a horizontal drill press with no limit on work length. Powered with SMITHway Electric Motor.



SMITHway ELECTRIC MOTOR, shown here reversed from its mounted position on the "Shopsmith," is a capacitor-start, single-phase, ½ HP motor, 1725 rpm, 115 volts. Double-shielded, prelubricated ball bearings, rolled steel frame, welded steel base for ceiling mount.

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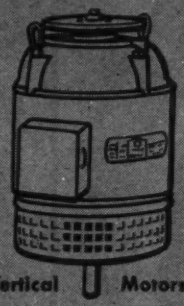
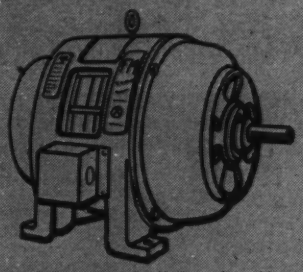


Vertical Motors



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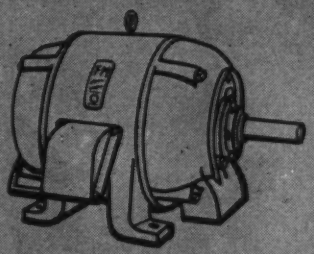
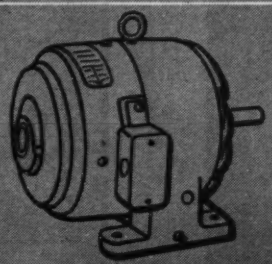


Splashproof Motors



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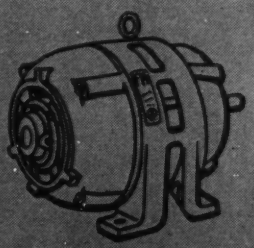
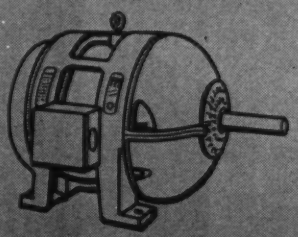


Multi-Speed Squirrel-Cage Motors



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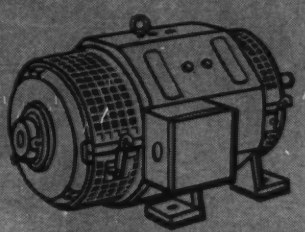

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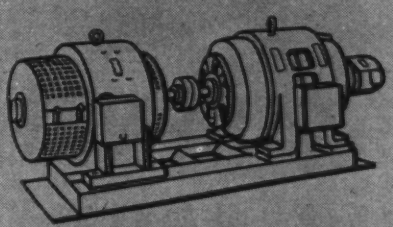

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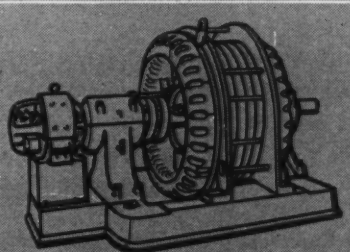
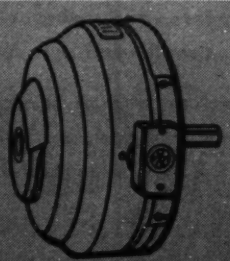
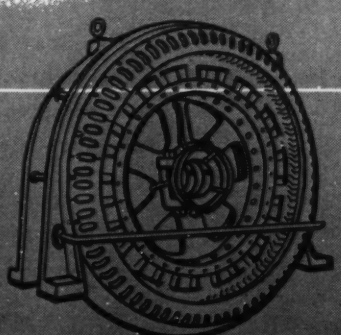


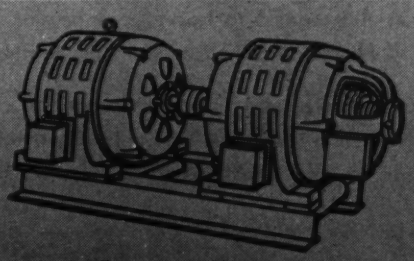
High-Speed A.C. Generators



Axial Air Gap Motors

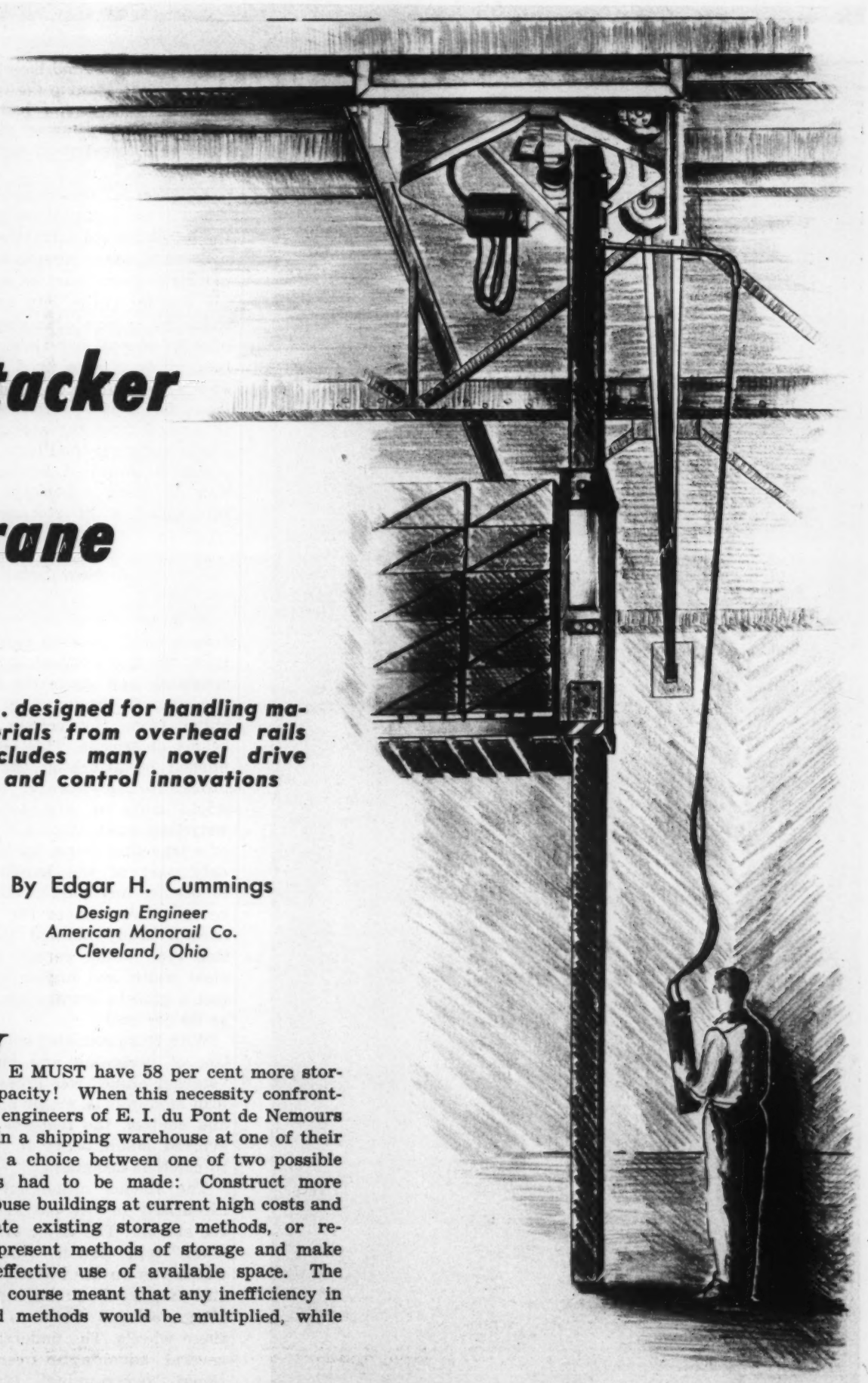


Low-Speed A.C. Generators



Frequency Changer

Stacker Crane



. . . designed for handling materials from overhead rails includes many novel drive and control innovations

By Edgar H. Cummings

Design Engineer
American Monorail Co.
Cleveland, Ohio

WE MUST have 58 per cent more storage capacity! When this necessity confronted the engineers of E. I. du Pont de Nemours & Co. in a shipping warehouse at one of their plants, a choice between one of two possible courses had to be made: Construct more warehouse buildings at current high costs and duplicate existing storage methods, or revamp present methods of storage and make more effective use of available space. The former course meant that any inefficiency in the old methods would be multiplied, while

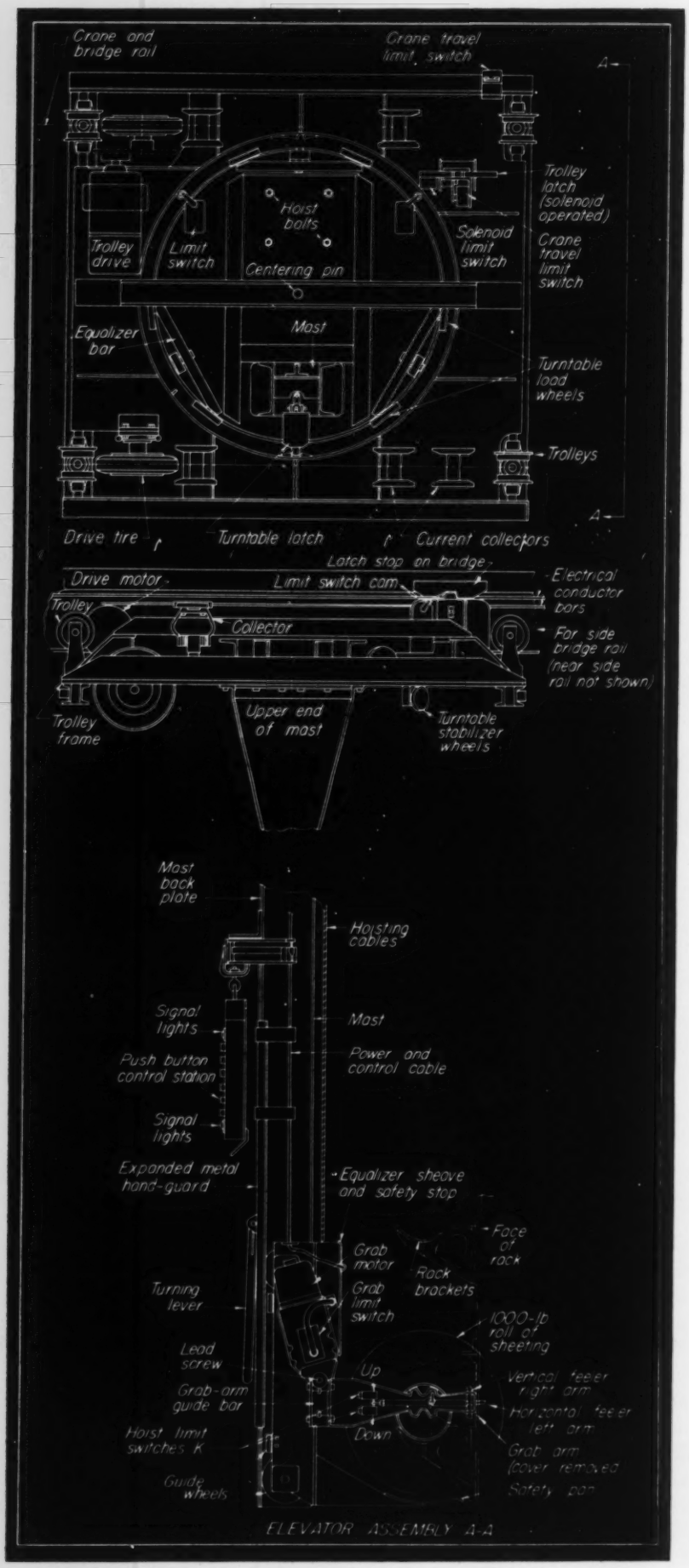


Fig. 1—Plan view and elevation of the roll stacker crane showing the various elements and control features

the latter offered attractive possibilities.

Storage space cannot be utilized 100 per cent; there must be access provided for moving goods into and out of the space by means of aisles between the piles of stored materials. Every square foot of floor area used for aisles and every cubic foot of unused space between the tops of stacks and the ceiling is wasted from the storage standpoint. Under optimum conditions no aisle space would be required beyond that necessary to allow a package to be moved into and out of storage position.

A New Solution

From an overall analysis of the problem, a novel solution seemed feasible—move the space consuming handling elements up and above the potential storage space by hanging the stacking machine from the ceiling on overhead beams or trusses. This could be accomplished by attaching lifting fingers or prongs to an elevator element which would move up and down on a rigid swiveling mast connected to the trolley of a traveling crane. By this method the only part of the handling equipment to occupy any part of the aisle would be the lower end of the rigid mast. A careful study showed that a unit of this type would permit a reduction in aisle width and higher stacking to effect a gain in storage space of as much as 60 per cent.

With this promising solution, the problem of designing and building such a "stacker crane" was presented to American Monorail. A major problem in drive and control, the features of the design evolved should prove of general interest to machine designers.

The stacker crane unit is composed essentially of two parts; the crane and the stacker. The crane is of the "underslung" type, that is, with trolley wheels which run on the bottom flanges of special shapes rolled from high-carbon, low-alloy steel and the loads are hung from these wheels. The underslung crane has several advantages over the conventional "overrunning" type of heavier

crane common in the metalworking and steel producing industries. Principal among these advantages is the facility with which a single long crane may be hung from a multiplicity of runways under a long-span roof or floor truss. This allows a single stacker or carrier unit to serve every inch of floor space within a building except for unavoidable marginal losses near walls or columns.

Underslug Crane Advantageous

Another advantage of the underslung crane lies in its interlocking feature. Underslung interlocking cranes may be so designed that a trolley or carrier may be moved from one crane to another through an interlocking joint between the bridges. This is particularly desirable when a number of stackers may be called upon to serve the same storage or working area on a number of cranes; a method with the utmost in flexibility but obviously more expensive than the single crane.

A modification is necessary in the interlocking crane system when the area to be served is broken up by intermediate columns or other obstructions at ceiling height. Columns create "blind spots". It is obvious that crane ends cannot pass columns and still be long enough to meet the end of the crane in the adjoining bay. The answer to this blind spot is the interlocking crossover—a short length of fixed rail supported from the runways of the adjoining cranes and long enough to bridge the gap between the cranes. Stackers and their loads may be moved by this means from a crane in one bay to a crane in an adjacent bay and so on. Obviously in plants where ceiling elevations are not widely variable it may be possible to carry a load from one corner of a building or group of buildings to the diagonally opposite corner without removing it from the grab or lifting forks.

To provide the trolley stability that is a necessary attribute of the rigid-mast stacker unit, the crane must be of the double-bridge type. From this double-bridge crane is supported the stacker unit proper which is composed of three moving parts; the trolley, the turntable-mast, and the lift or elevator, *Fig.* 1. In its simplest form the elevator comprises a "car" with guide wheels and forks or prongs for lifting loaded skids or palleted merchandise up the mast and depositing it on a stack or rack.

Particularly interesting among the unusual applications are those in which the clearances along and between the racks are such that all routes and destinations must be clearly defined by latching positions, limit switches or indicator lights, and in which the electrical circuits must be interlocked to prevent travel beyond designated locations. One such application involved the loading of 1000-pound rolls approximately 48 inches long by 24 inches in diameter.

Starting with a roll for storage the stacker moves along the main aisle and as it passes the center of each side aisle indicator lights glow and inform the operator when he is in proper position to pass between the racks. When the operator reaches the rack for which the load is bound he must check his indicator lights for aisle position and then rotate the mast to the "left" or "right" position before the limit switches on the turntable above close the trolley drive circuit and allow him to move the stacker along the crane bridge and into the side aisle. When the stacker has almost reached the rack position desired, the operator releases the trolley travel pushbutton and a solenoid latch on the trolley operates to engage a slot on the crane bridge, *Fig.* 2. When this latch bolt is in proper position the crane travel cir-

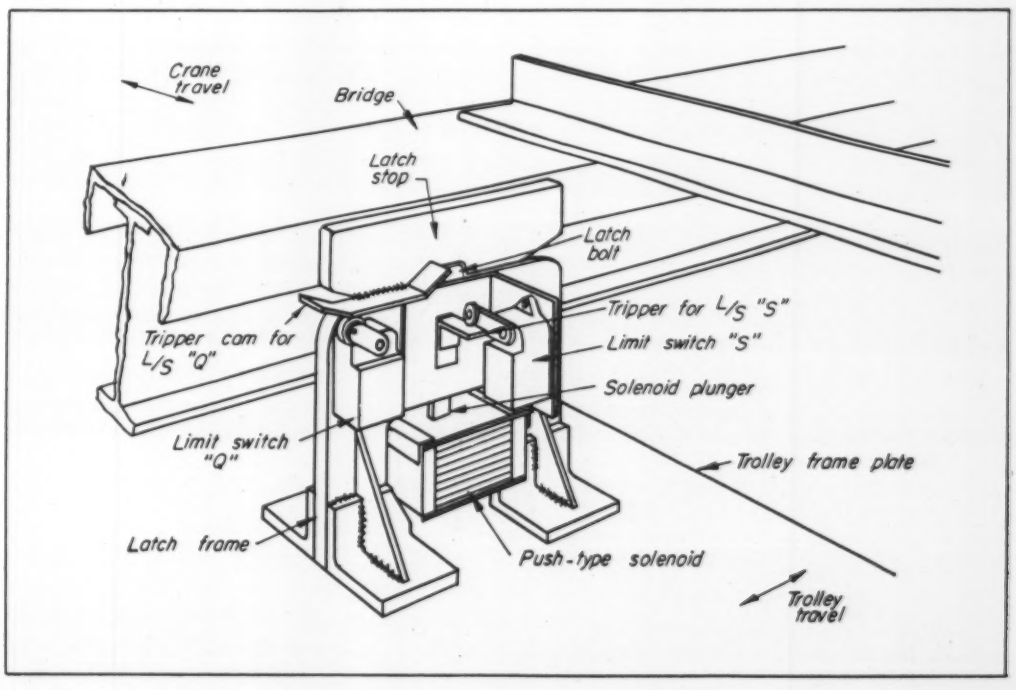
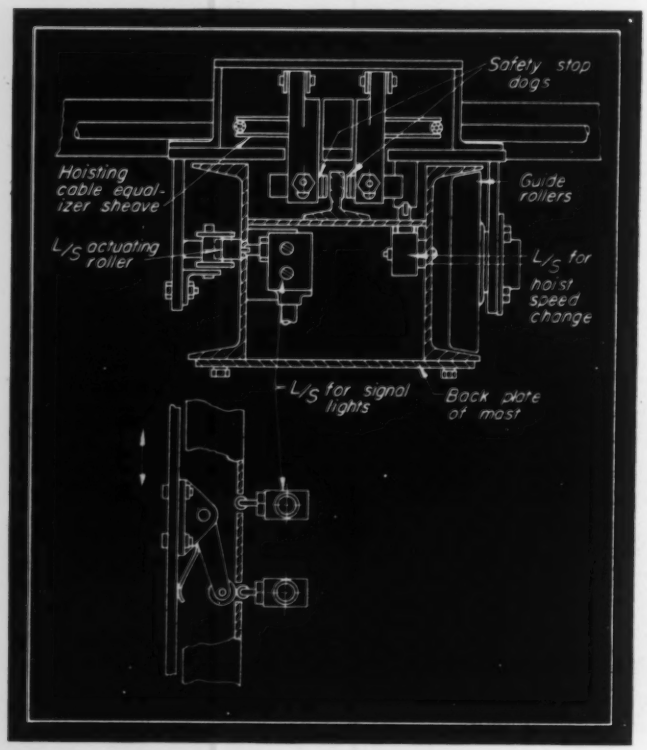


Fig. 2 — Solenoid latch mechanism for the stacker which locates the desired rack position automatically

cuit is automatically reclosed. Hoisting is now begun and the operator watches signal lights on his pushbutton box. As the roll passes each bracket elevation on the structural loading rack, an amber and a green light flash. At the approximate position desired the operator watches the amber light and stops and jogs the hoist as necessary to keep the amber light lit. With the roll in this position it can be moved into the rack and over the storage bracket. A feeler which operates a limit switch protrudes horizontally from the end of the left-hand grab arm and stops crane travel when contact is made with the face of the rack, *Fig.* 1. The elevator is then lowered several inches until the green light at the pushbutton comes on. This means that the roll mandrel is resting on the bracket and the grab arms may be retracted. If the elevator should be lowered or raised too far while in contact with the rack, limit switch feelers on top and bottom of the right-hand grab arm will stop the hoist motor, *Fig.* 1. When the grab arms have opened to the limit of their travel they may be raised again to the amber light position and the crane may be backed away to the center of the aisle.

From a design standpoint this piece of equipment might be called a structural machine. The design requires good judgment as to where carefully machined parts and close tolerances should be used and where such precision is unwarranted. For example, the mast of the unit is a modified box section built of structural channels and plates; the eight-inch hot-rolled channels, under standard mill tolerances, may vary from 7 29/32 to 8⅛ inches in depth, from 2 15/32 to 2¾ inches in flange width and the outside faces of the flanges may be out of parallel as much as 1¾ degrees. These channels serve as guides for the wheels which are built into the traveler element. Obviously it would not be feasible to design a practical traveler or elevator with a high degree of precision and expect it to travel up and down this mast and maintain perfect alignment and linearity of motion.

Fig. 3—Sections through the crane mast showing the safety mechanism and arrangement of position and speed control switches in the mast to the crane



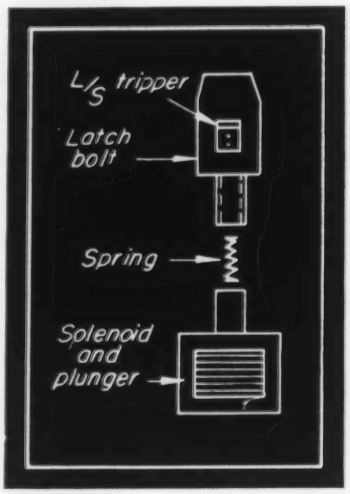


Fig. 4 — Exploded view of the solenoid arrangement showing the spring-loaded design

The elevator element of the roll handling stacker has grab arms of malleable castings which not only lift the load but completely enclose the limit switches and operating mechanism of the feelers. These arms are mounted on a heavy guide bar and the mast end of each arm contains a nut which runs on a lead screw having opposite-hand threads. This lead screw is driven through enclosed mitre gears by a fractional horsepower gearmotor. A screw type limit switch stops opening and closing of the grab arms at the proper points for engaging or releasing the roll. The arm guide bar is bolted securely to a plate fabricated structure which fits around the front and sides of the mast and carries all the guide wheels and rollers necessary for maintaining elevator alignment on the mast.

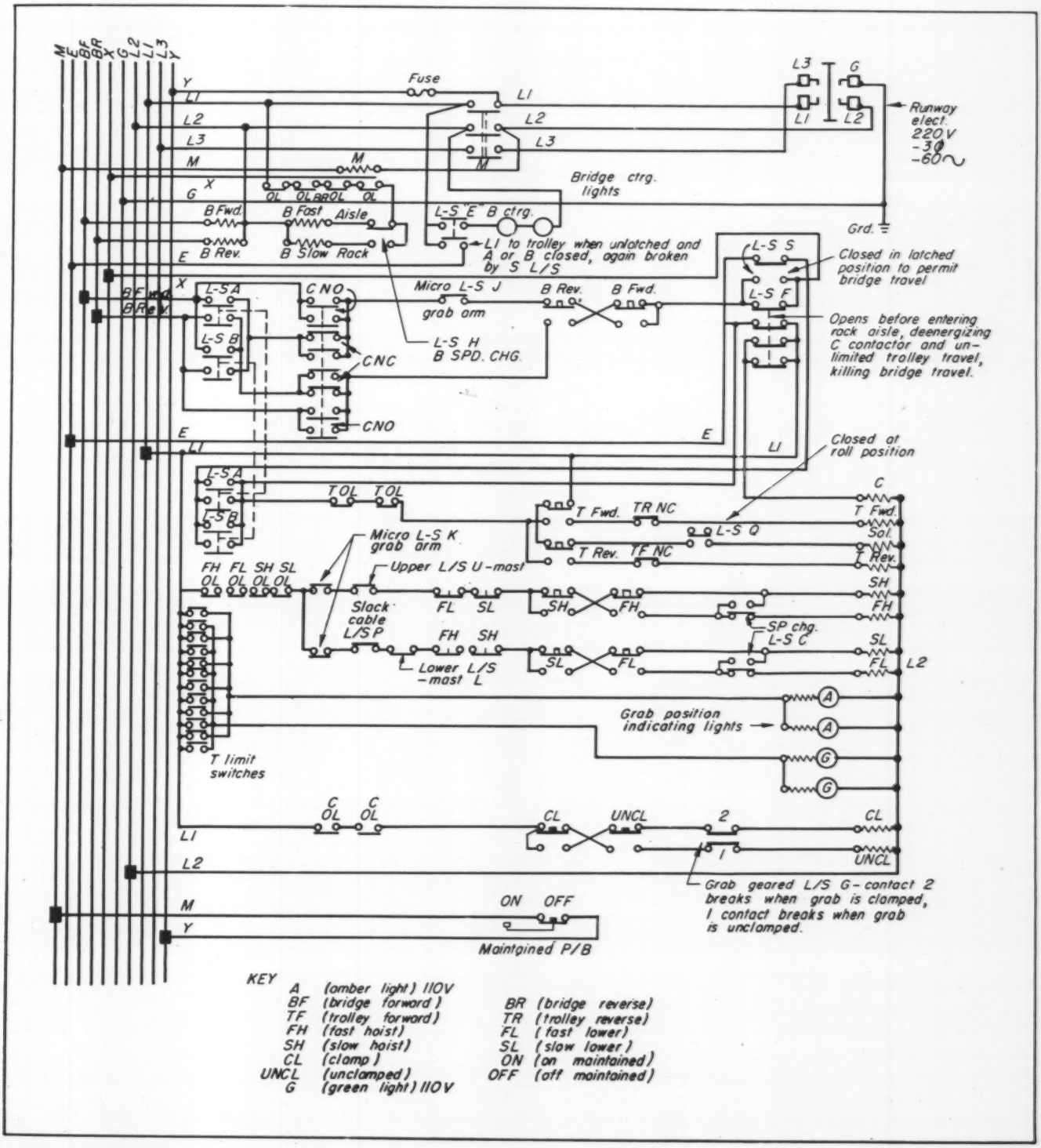
Also mounted on this plate structure is the equalizing sheave assembly. This is a floating unit which is normally lifted to the top of its ways on the elevator by the hoisting cable. Should the sheave drop from its proper place due to cable breakage it will immediately operate a linkage which clamps hardened, toothed eccentric jaws on the vertical rail in the face of the mast, *Fig.* 3. This prevents a fall of the load and simultaneously operates a slack cable limit switch to stop the hoist motor. Underneath the roll position is a safety pan which is intended to catch the roll should it slip from grab arms or rack brackets due to improper operation.

Between the left side plate and the mast is a

spring-loaded roller which runs on the side of the mast and depresses the Microswitch plungers projecting through the inside, *Fig.* 3. These limit switches control the position indicating lights on the push-button box.

Considerable difficulty was experienced with the masts of early models due to lack of torsional rigidity, but present design has ample strength and stiffness both in torsion and bending to resist combined forces due to acceleration of the load and eccentric loading of the mast. The backplate is removable to permit easy access to all the limit switches for indicating elevator position and for slowing and stopping the lift at the upper and lower ends of the mast. On the back of the lower end of the mast is

Fig. 5—General schematic wiring diagram for the roll stacker with details of the position control lights



attached the turning handle with the latch rod which extends upward to the turntable latch. Expanded metal guards at the operator's position are installed to minimize danger of crushed fingers between the guide wheels and mast. Cable reels bolted to the top of the mast pay out power supply wires to the grab motor and the limit switches.

Under the turntable is mounted the twin-drum electric hoist which lifts the elevator and grab. On the turntable at three equidistant points on the periphery are mounted equalizer bars and six load wheels; this provides the utmost stability and distributes the load around the circular track, *Fig.* 1. Due to the small size of the turntable as compared to the height of the mast it is easily possible that sudden stops or acceleration might cause the load wheels to rise from the track on one side or the other. "Kick-up" wheels are provided therefore below the turntable plate to run on the underside of the circular track. A spring latch operated through a pull rod from the turning lever below snaps into a notch at any one of three positions spaced 90 degrees apart. These are the "right", "left", and "center" positions as the operator faces into the rack aisles. Due to the fact that the load wheels are flangeless, a center pin is required and operates in a bearing supported from the trolley frame.

The trolley frame into which the turntable fits is essentially a heavy horizontal plate stiffened with vertical ribs. This frame is a complex indeterminate structure of which a careful analysis would yield extremely doubtful results under variable conditions of stress imposed by the loaded and moving mast below. It was felt that the probable chance of the inefficient use of considerable weight of steel was excusable in order to save hours of engineering time in stress analysis. Stiffness of the frame is enhanced by the centering bridge; a heavy channel which crosses the frame and guides the center pin of the turntable.

Resilent Solenoid Latch Used

On the main plate of the trolley frame is mounted the solenoid latch which engages the notched latch plates on the crane bridge, *Fig.* 2. The solenoid is connected to the latch bolt through a spring which allows the solenoid plunger to complete its stroke before the latch bolt has seated itself in the notch on the crane bridge, *Fig.* 4. This feature minimizes danger of solenoid burnout due to high current flow while the plunger is not fully within the coil. Mounted on the solenoid latch are two limit switches; one of these, limit switch *Q*, closes the solenoid operating circuit only when the latch is within a few inches of the latch-stop position. This prevents use of the solenoid at places other than at the rack locations. The other, limit switch *S*, operates from a tripper on the latch bolt itself and closes the crane travel circuit. This feature makes it impossible to move the crane while the stacker is in a rack aisle unless the latch bolt is properly seated in a latch stop on the crane bridge. The general schematic wiring diagram for the stacker discussed is shown in *Fig.* 5.

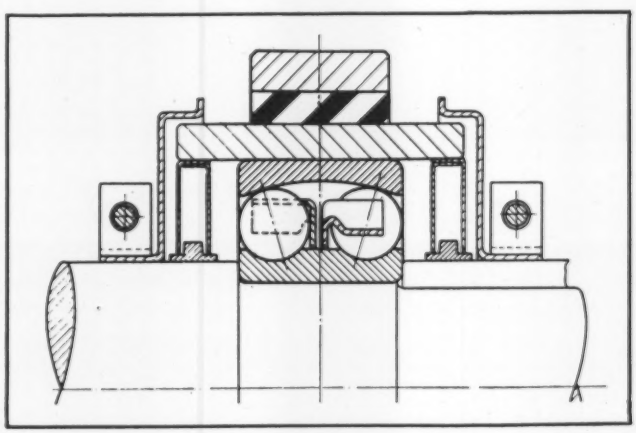
Also on the main plate of the trolley frame are mounted the drive motor, shaft, and rubber-tired traction wheels. Current collectors in sufficient number to take care of control and power requirements are supported on brackets between the trolley wheels and make contact with the conductor bars on the crane bridge.

While the features discussed here are probably the most interesting of the stacker crane applications, other systems of various types are now in use or in process of manufacture. Some of these are completely motorized as to crane travel, trolley travel, hoisting, and rotation. Further improvements and refinements are contemplated striving toward minimum space requirements for handling equipment. This implies closest possible approach of the trolley to the end of the crane bridge and of the crane to the end of the runway and also the highest possible lift of load. Any degree of success in these aims will be reflected in more efficient use of storage space.

The author wishes to acknowledge with thanks the kind cooperation of Mr. Fred A. Miller and E. I. du Pont de Nemours & Co. in making available the illustrations and data used in the preparation of this article.

Resilient Bearing Mount

MISALIGNMENT is accommodated and vibrations are arrested by an improved SKF self-aligning propeller shaft bearing. Primary function of the device is support of the shaft in proper position in



vehicles whose shafts are of such length as to require an intermediate bearing. By mounting the ball bearing with a sliding fit, permitting endwise freedom in the shaft box, no load is imposed by misalignment. The rubber cushion is "shot" between the two rings of the housing at high velocity and held in place by mechanical friction, thus eliminating the need for bonding.

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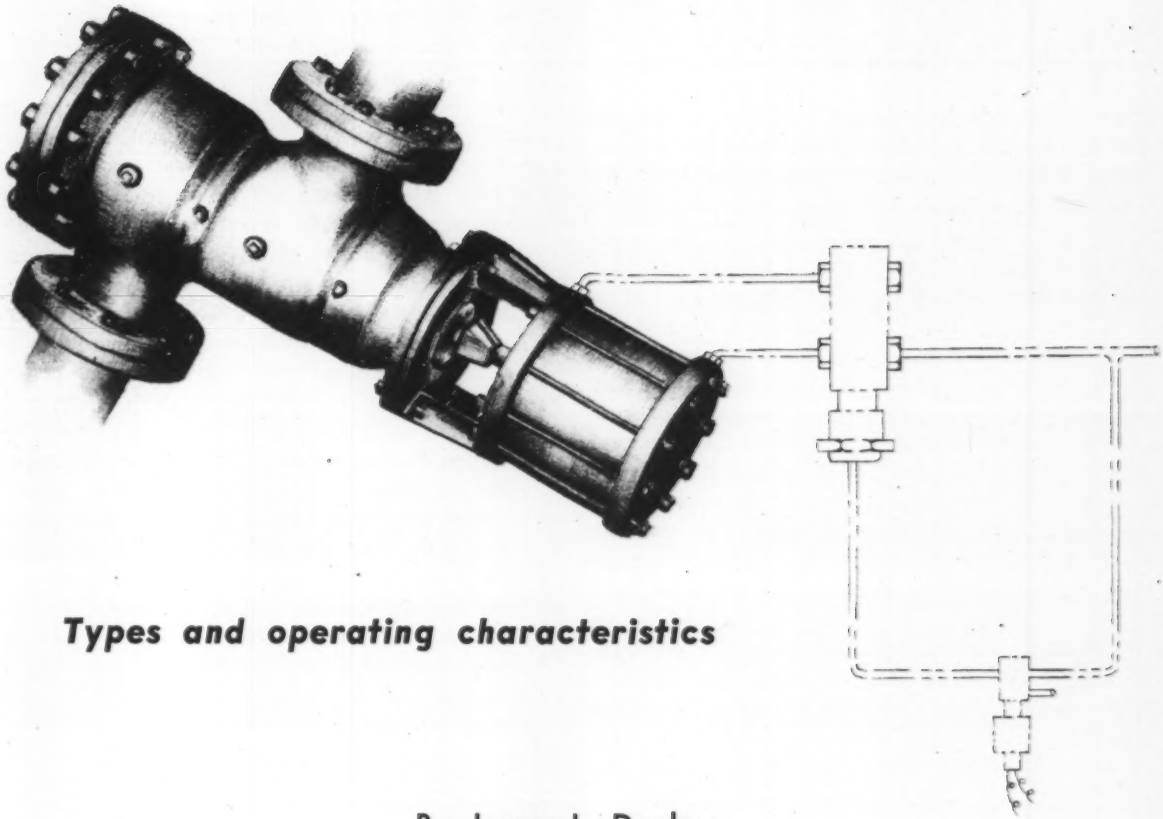
Pneumatic Relays



Types and operating characteristics

By James L. Dooley
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Venice, Calif.

A RELAY is described by the dictionary as a fresh set of anything to replace or relieve a tired set. This description is particularly applicable to pneumatic relays although it originally was intended for teams of horses on the road or runners in a foot race. However, in recent years, the technical meaning of the word has been extended to include not only those devices which duplicate the original signal (pressure or mass flow) but also devices which put out a rectified, amplified, or otherwise modified signal.

In its simplest form, the pneumatic relay is merely an air operated air shutoff valve as shown in *Fig.* 1. This type of unit is frequently used to control large air flows with a small control line from a remote control valve or to separate operations of one pneumatic circuit from another. It is a full-on full-off unit and has no provisions for relaying intermediate

pressures. A three-way relay valve of different construction but of the same general type is shown in *Fig.* 2. Both of these general types are in common use in pneumatically controlled machinery and take many forms to include pneumatic, manual, electrical, and mechanical overrides or interlocks. These valves are the pneumatic equivalent of the common electrical relay.

Relays Permit Faster Braking

In pneumatics, however, relays very frequently will modulate the output pressure or capacity to be some function of the incoming signal. Some units are designed to handle a large flow capacity and regulate accurately to a definite pressure equal to the small flow signal supplied to the valve. A relay of this type, an air operated air brake valve, is shown in *Fig.* 3. Where the time of operation is important, as in this particular application, faster operation can be obtained by locating the high-capacity relay valve adjacent to the wheel to be braked and operating it with a small air line from the remotely located application valve which acts as a pilot for the relay valve. Since this valve will relieve the brake pressure to atmosphere as well as apply air to the brakes, it is particularly desirable to locate it near the brake drum so the low pressure air does not have to flow back to the remotely located application valve when the brakes are released. There is a whole family of pneumatic relay valves used in aircraft, automotive, and railway braking to speed up brake operating time and insure that the system will "fail safe" should difficulties occur, but it is beyond the scope of this article to go into their details here.

Another application of a pressure modulating type relay is shown in *Fig.* 4. This unit controls the flow of high pressure inlet gas to maintain an output pressure equal to the pilot or control signal supplied to the lower side of the diaphragm. The design is such that large variations in upstream pressure have no influence on the accuracy of the unit. A pneumatic relay designed for pressure multiplication is shown in *Fig.* 5*a* and one for pressure division in *Fig.* 5*b*. In these units the incoming pressure signal is applied to the upper diaphragm which transmits a force proportional to the effective area and the pressure applied. The transmitter section comprising the lower diaphragm and three-way valve operates to apply enough pressure to the lower diaphragm to give an equal and opposite force. This transmitted pressure is related to the incoming pressure signal as the inverse effective area ratio of the two diaphragms. The units shown in *Fig.* 5 were designed for use with the torquemeters used on large aircraft engines. The engine puts out an oil pressure signal proportional to the torque output from the engine, but under very cold operation the small static oil line from the engine to the gage on the instrument panel becomes sluggish or even blocked, giving erroneous indication. By converting the hydraulic pressure signal to an air pressure signal at the engine, these errors as well as errors due to differences in elevation are eliminated.

Since the principle of the pressure transmitter is used in many relays, the two basic types are explained schematically in *Fig.* 6. The essential difference between the two is in the method of valving. In one the inlet or exit port area is fixed so air must flow through it continuously while in the other a variable area inlet or exit port is used which is shut off when the unit is in equilibrium, i.e., when the pressure on the diaphragm is sufficient to balance the force applied. Both types deliver a gage pressure

Fig. 1—Below—Gas operated 500 psig air shut-off valve designed for low weight, low pressure drop applications

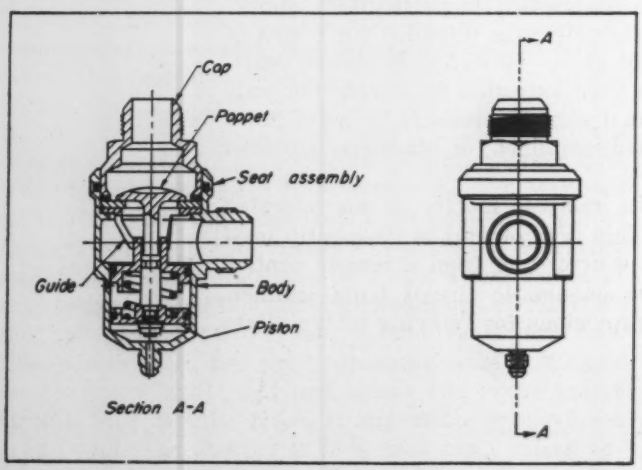
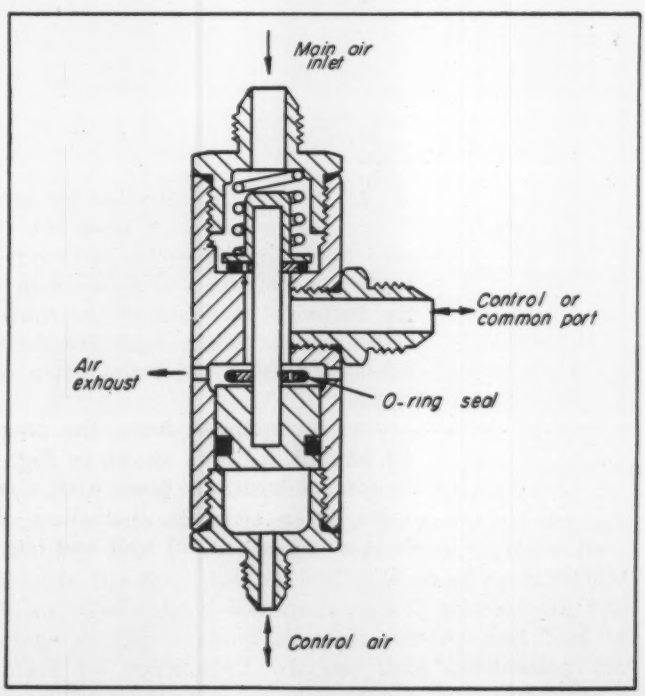


Fig. 2—Below—Air operated three-way relay valve similar in function to common electrical relay



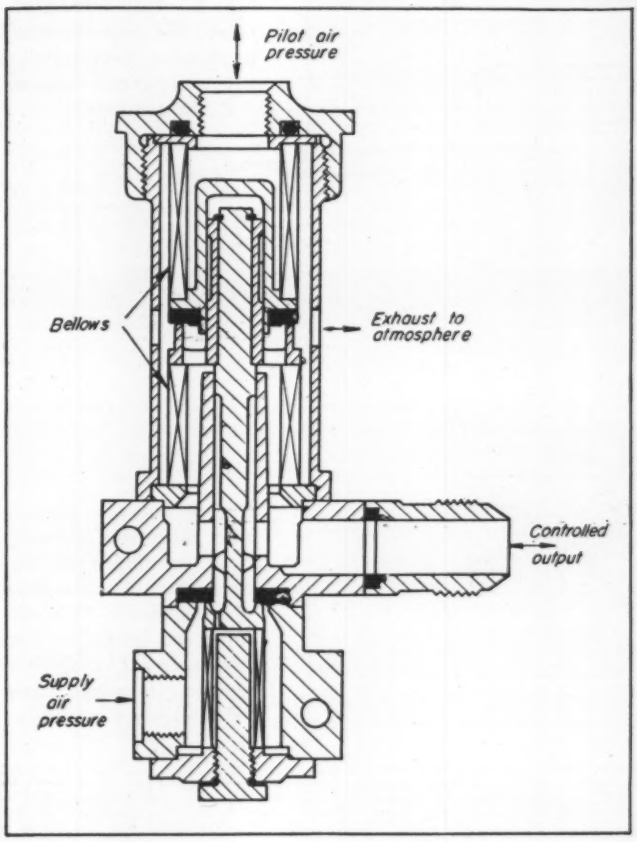


Fig. 3—Above — Brake relay valve. Such valves are mounted adjacent to the unit to be operated to obtain fast response

signal proportional to the force F applied as long as supply air is maintained. It should be definitely noted that since the transmitter delivers a gage pressure, i.e., a definite pressure above ambient atmospheric pressure, and since most recording or indicating devices are also based on gage pressure, variations in ambient atmospheric pressure have no influence on the accuracy of the equipment. Accuracies of plus or minus ½ per cent can be expected with carefully designed equipment.

Used In Rocket Motor Thrust Testing

A pressure transmitter designed for use with a dynamometer is shown in *Fig.* 7. It is of the type having variable inlet and exit port area. The advantages of the pneumatic relay for this work are that it can be remotely located and can be read or recorded on several instruments simultaneously. It is a rugged instrument and does not require frequent calibration. Among many other applications these units are used to measure thrust on hazardous rocket motor testing where accurate remote indication is required and the equipment must be extremely rugged to survive the severe vibrations and explosions. A pressure transmitter of the fixed inlet port area type is shown in *Fig.* 8. This particular unit is designed to handle extremely high pressures in corrosive gases. The Bourdon tube which is de-

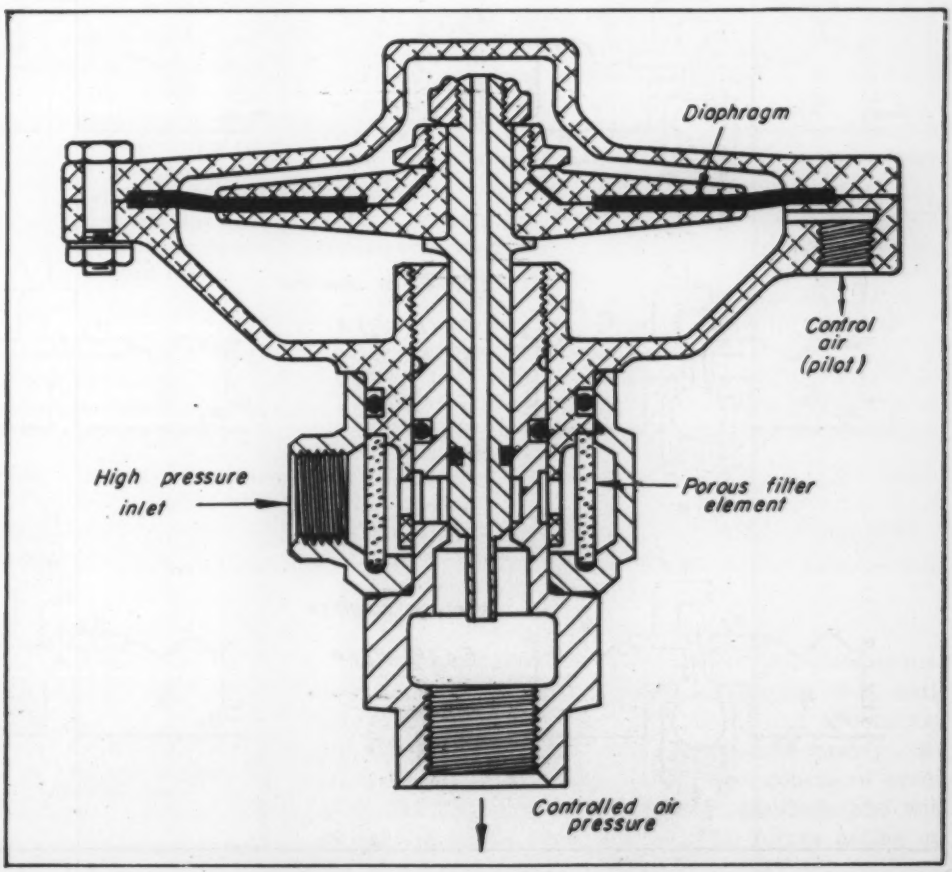


Fig. 4—Right—Pressure modulating type relay with balanced inlet valve

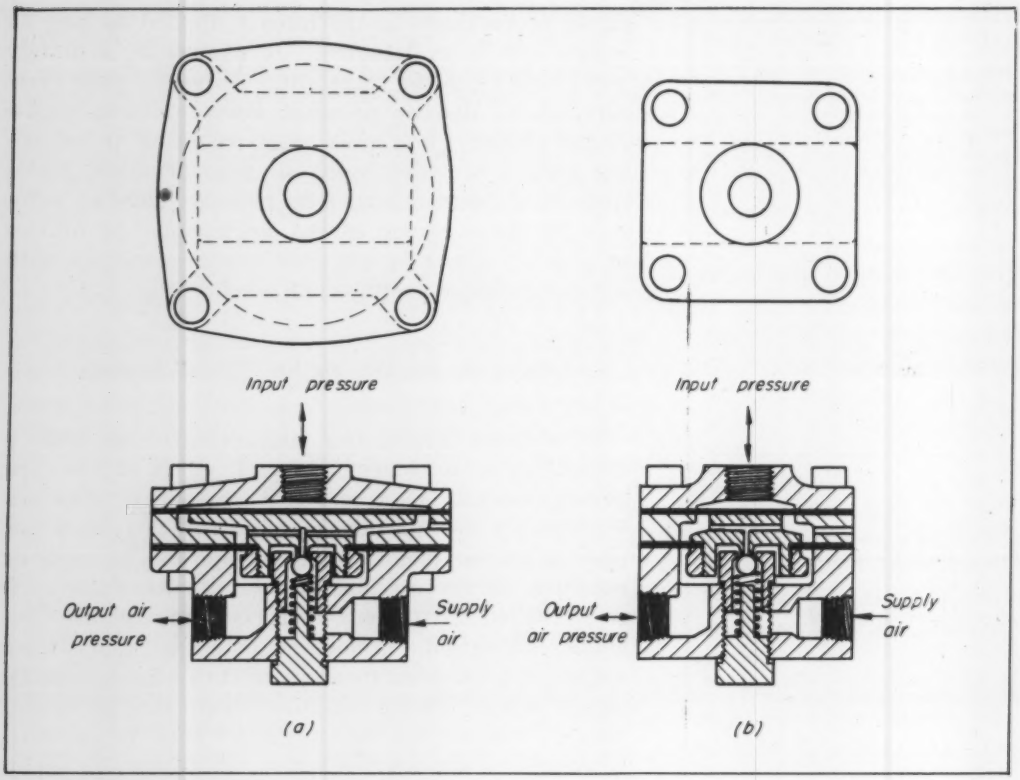
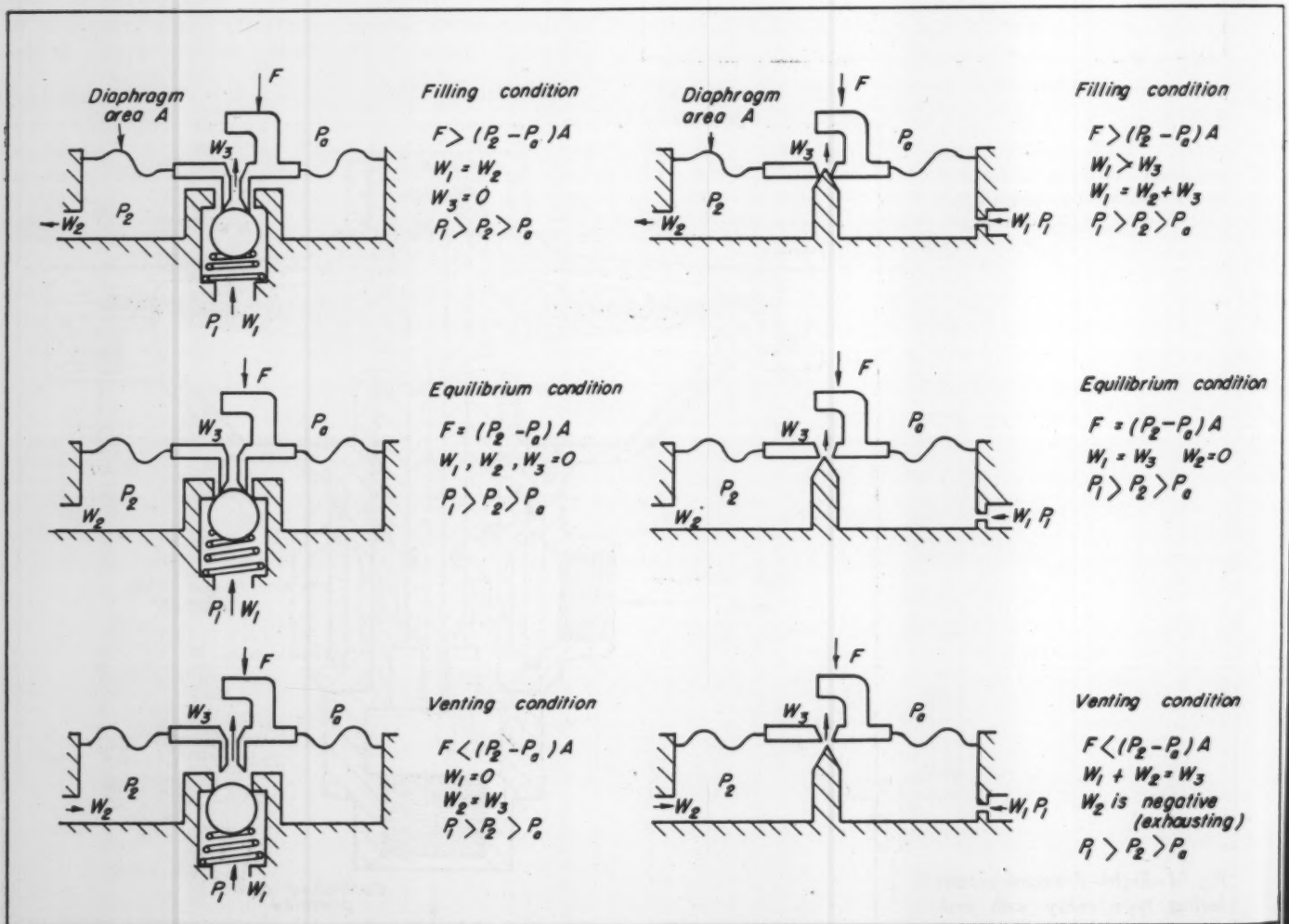


Fig. 5 — Left — Pressure relays for multiplication or division designed for use on aircraft engine torquemeters

Fig. 6—Below — Schematic diagrams showing flow conditions of static and continuous flow type pressure transmitters. In formulas F = force applied, W = weight flowing, and P = absolute pressure



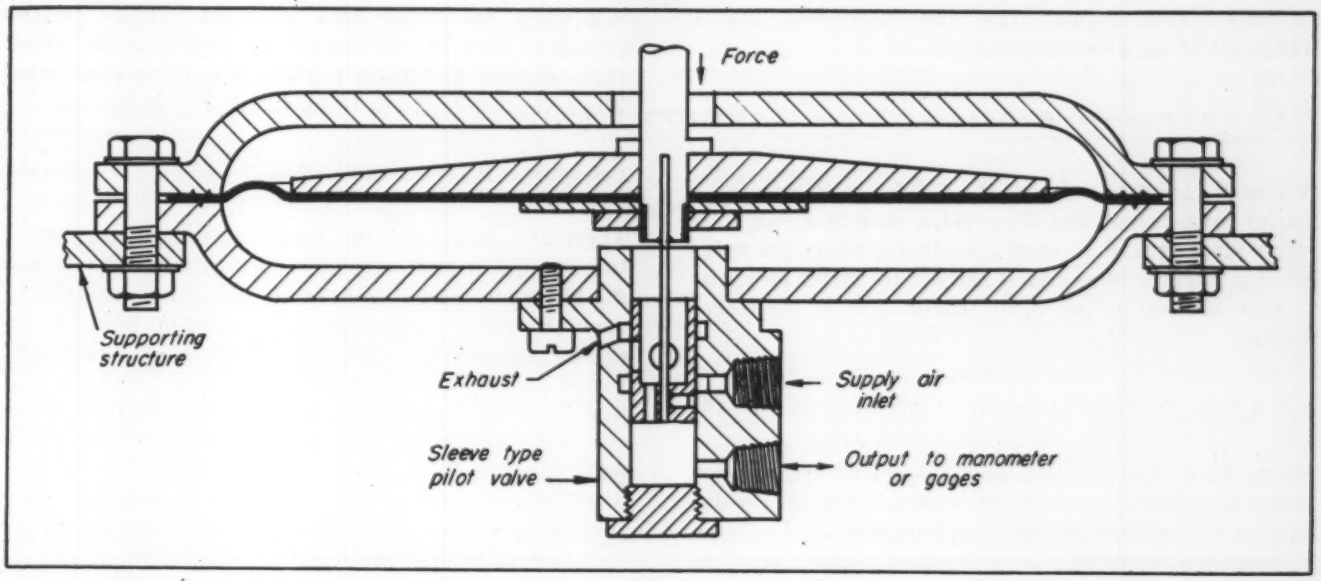


Fig. 7 — Above—Pressure transmitter for dynamometer torque indication

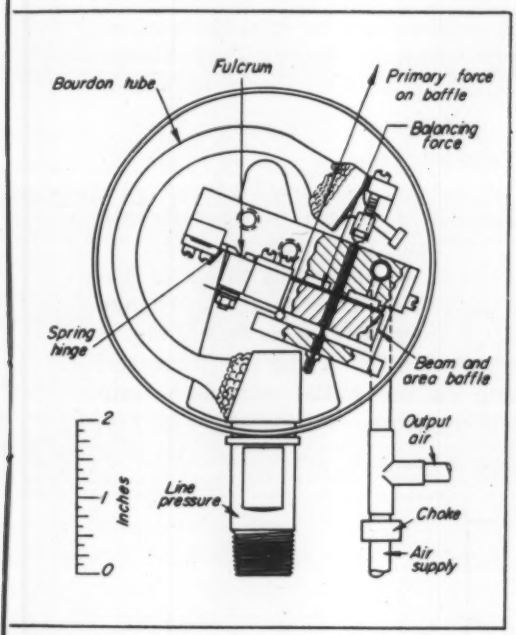
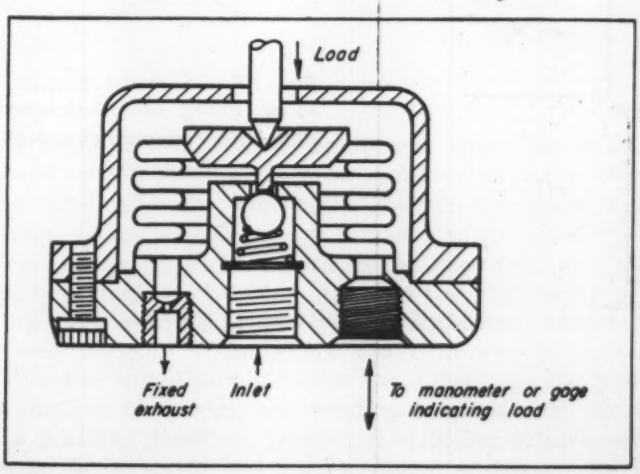


Fig. 8—Left—Pressure transmitter with fixed inlet area (choke) and variable exit area to give air pressure signal proportional to line pressure on Bourdon tube

Fig. 9—Below—Pressure transmitter with fixed exit port area, the reverse of that shown in Fig. 8



signed to handle the corrosive condition applies a force on the pneumatic transmitter proportional to the gas pressure and the transmitter in turn delivers the output air pressure proportional to this force. In general, air supply pressures are low (30-100 psig) to keep the orifice and valve size large enough to be practical and yet to keep the air consumption down. A transmitter of the type shown in *Fig.* 8 will use between 0.1 and 0.2-cubic feet of free air per minute. The reverse of this unit is shown in *Fig.* 9 where the air is bled from the system with a fixed orifice.

Both of these types with fixed inlet or exit orifices not only consume air continuously but are more sluggish than the type shown in *Fig.* 5, i.e., they do not recover equilibrium as quickly from a change in load. However, they are generally a little more accurate since there is no possibility of a null point at the equilibrium condition.

In a modulating type relay errors may be caused by the following:

1. Variations in the forces acting on the valves proper at different pressure conditions and at different flow conditions
2. Friction. Mainly static breakaway but also kinetic involved in moving the elements of the relay to a new position. Also friction in the diaphragm elements
3. Changes in the effective diaphragm area with movement
4. Thermal changes in the flexibility of materials and clearances between parts
5. Mechanical lost motion
6. Inertia.

To minimize the above sources of error, the transmitters should have a large diaphragm area with minimum valve lifts and port areas and a constant air supply pressure no higher than is necessary. At moderate or high pressures the first source of error is by far the most important in magnitude and will be considered in more detail. The forces acting on

a conventional poppet type inlet valve, *Fig.* 10*a*, at the point of incipient opening are

$$F = P_1A - P_2(A-a) + S - P_3a + f_{static} \quad \ldots\ldots\ldots\ldots (1)$$

where F = force on stem, P_1 = inlet pressure, P_2 = outlet pressure, A and B = valve sealing areas, a = valve stem area, S = spring load, and where the valve seating surface is assumed subject to outlet pressure.

Just as soon as the valve starts to open the forces become

$$F' = P_1B - P_2(B-a) + (S+\delta N) - P_3a + f_{kinetic} \quad \ldots\ldots (2)$$

where N = spring scale, and δ = valve lift, and assuming that the pressure P_1 exists across the valve seat at the instant the valve is cracked.

Examination of the magnitude of these forces as shown in *Fig.* 10*a* will indicate that F is greater than F' unless the spring scale is very high. This means that as soon as the force is great enough to crack the valve, it will have a tendency to snap open. It should be noted that the spring cannot be adjusted to overcome this condition. At very small openings the Bernoulli effect counteracts this snap opening and may be sizeable if the drop across the valve is high and the valve seat is wide. This merely delays the difficulties, however, until the valve is opened farther. This will be examined in more detail in the following discussion.

When a pressure balanced inlet valve is used as shown in *Fig.* 10*b*, the forces at incipient opening are

$$F = (P_2 - P_3)a + S + f_{static} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

neglecting the small area difference (equal to the projected area of the valve seat) between the upper valve surface and lower surface plus valve stem area. When the valve starts to open, the forces become

$$F = (P'_2 - P_3)a + (S+\delta N) + f_{kinetic} \quad \ldots\ldots\ldots\ldots (4)$$

where P'_2 represents the resultant pressure assumed to exist below the valve after it starts to open. Since P'_2 is larger than P_2, obviously the force required to open the valve increases as it is opened, but this increase is small if the valve stem is small. Balanced valves always impose additional sealing problems and can only be justified where accurate control is required or where the upstream pressure varies over a wide range.

Pressure-Velocity Relationship

The Bernoulli Theorem of fluid flow states that at any point in the flow passage, *Fig.* 11*a*, the sum of the pressure energy, potential energy, and kinetic energy is a constant, or

$$P + hdg + \tfrac{1}{2}dv^2 = \text{Constant} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where P = pressure, h = height above reference plane, d = density of fluid, g = gravity, and v = velocity of flow. Now if we apply this to air or gas flowing through a valve, *Fig.* 11*b*, where the change in height above the reference plane is negligible, it is evident that as the velocity of the gas increases, the pressure (acting on the walls) decreases since the sum of these two factors is constant. In *Fig.*

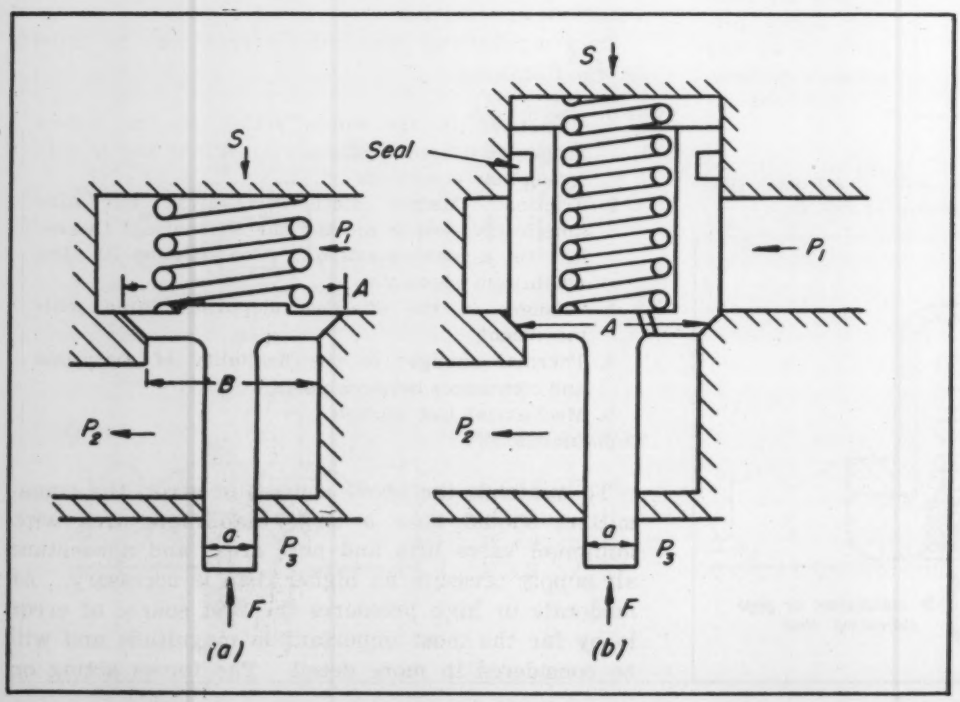


Fig. 10 — Sketches showing forces acting on unbalanced and balanced poppet valves at opening

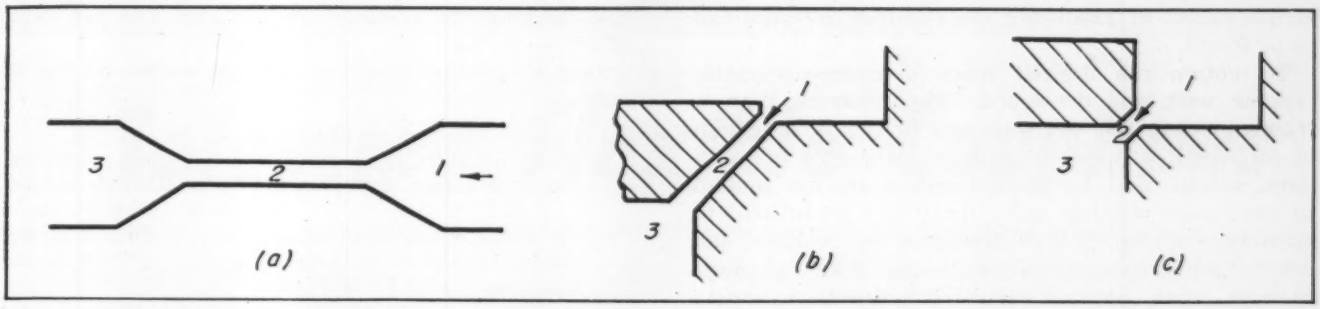


Fig. 11—Diagrams to illustrate Bernoulli Theorem of fluid flow as it affects pressure

11*b* the velocity of the air at the inlet (1) is very low, therefore the pressure acting on the walls is high. In the cracked position, however, the velocity across the valve seating face (2) is high so the pressure acting on the face is reduced. This causes a pressure force tending to resist opening or to return the valve to the closed position. This effect occurs only when the valve is cracked open and can be minimized by using very narrow seats and maintaining large flow passages in approaching and leaving the seat, *Fig.* 11*c*.

Leakage in either the inlet or exhaust valves of a relay is almost impossible to eliminate since the seats are very lightly loaded at the equilibrium condition. It should be noted, however, that in many applications small leakage improves the accuracy of the relay. This leakage can be minimized with good mechanical design to insure alignment and minimize friction effects.

In contrast to the electrical relay field there is very little standardization of pneumatic relays, so almost every unit must be designed to fit the job, resulting in a great variety of designs and inherent comparatively high cost.

Booster Supplies Hydraulic Pressure

Electrically controlled unit operates on shop water and air supply lines to provide high-pressure hydraulic actuation

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PRIMARILY, portable equipment must be light and easily manipulated so that fast production can be obtained by the operator. Pneumatic electric resistance welding guns, using normal factory air supply, are unable to provide adequate pressure without the use of heavy, cumbersome cylinders. Likewise, there is the problem of obtaining high welding pressures with equipment used in confined working areas where the bulkiness of pneumatic cylinders would prohibit their use. Obviously, the pressure cylinders composing the welding gun must be as small as possible. However, pneumatic cylinders of such reduced dimensions would not give adequate pressure, and some

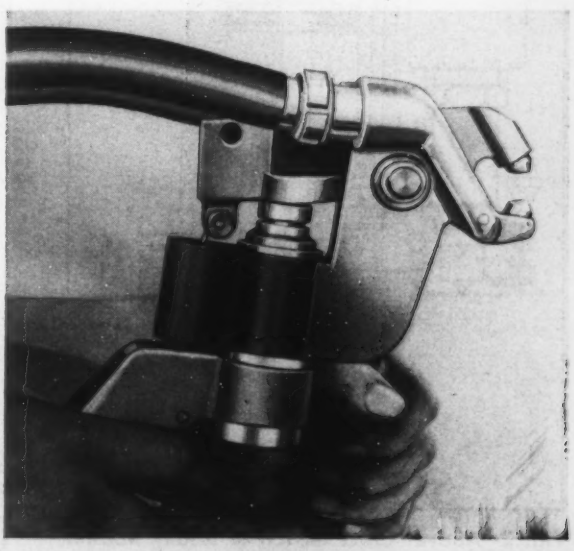


Fig. 1—A compact, lightweight gun for welding drip rail to roof of a passenger car. Use of the booster kept the maximum weight approximately 5½ pounds

simple means of producing the required pressure had to be found.

To obtain the desired force a hydro-pneumatic booster unit was developed. The pressure that is transmitted to the electrode tips of the welding gun is sufficiently increased to permit a design of minimum weight, *Fig.* 1. These boosters are not limited to resistance welding only. They can be utilized to advantage whenever high pressures are required and where limited space prohibits the use of air cylinders. In such cases, reduced diameter hydraulic cylinders can be used, the booster providing the pressure source.

Two liquids feasible for use in a hydraulic system are water and oil. Using hydraulic oil pressure was not an attractive solution because inherent minor oil leaks, which are bound to occur under production conditions, create messy conditions about the work and rapid deterioration of hoses and rubber-covered current carrying cables. The use of water as a hydraulic medium permits a more simplified system. The supply is from the same line used for cooling transformer, cable, and gun. It eliminates many of the objections to oil, such as messiness, because it evaporates quickly and can be mopped up easily, and it does not affect the rubber coverings.

Design of the booster unit is shown in *Fig.* 2. The seals between the two chambers are designed to keep the air and water from bleeding from one into the other. This unit also has the additional feature of by-passing any such leakage from either chamber to the atmosphere. The return stroke of the ram brings it past the water refilling vent and if any void has resulted from water leakage, the void is automatically refilled by the factory water supply line, making the pressure of the ram 100 per cent effective in the next working stroke.

Design specifications for the unit shown in *Fig.* 2 are:

3 $\frac{5}{16}$-inch diameter air piston (4 $\frac{1}{2}$-inch max. stroke)	9.968 sq in. area
1-inch diameter high-pressure ram	0.785 sq in. area
1 to 12.5	pneumatic-hydraulic ratio
937 pound hydraulic pressure	at 90 pounds air
Volume at 4-inch effective stroke	3 cu in.
Maximum overall dimensions	4 $\frac{3}{4}$-inch diameter x 15 inch high

When the piston is in the upper position, water from the line is admitted into the hydraulic system through the water intake and passes through the small plunger orifice and into the pressure chamber.

In order to obtain stroke and pressure on the welding gun, the operator energizes the electrovalve, a cross section of which is shown in *Fig.* 3, through the electrical sequence of the welder. Pneumatic pressure actuates the booster plunger and water is sent into the piston of the portable gun to squeeze the parts which are to be welded. The moment the orifice is below the inlet, there is no longer a direct connection between the hydraulic chamber and the water supply line. The operating cycle with the electrovalve operating is shown in *Fig.* 4.

When the electrical sequence changes the position of electrovalve so that the pneumatic piston comes back into the original position, the water which is admitted into the portable gun cylinder will be pushed back into the hydraulic chamber, *Fig.* 4. This is accomplished by a spring located in the cylinder of the welding gun.

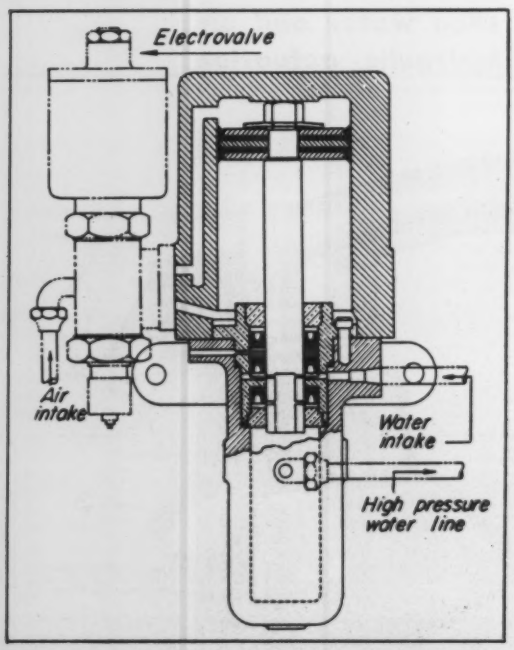
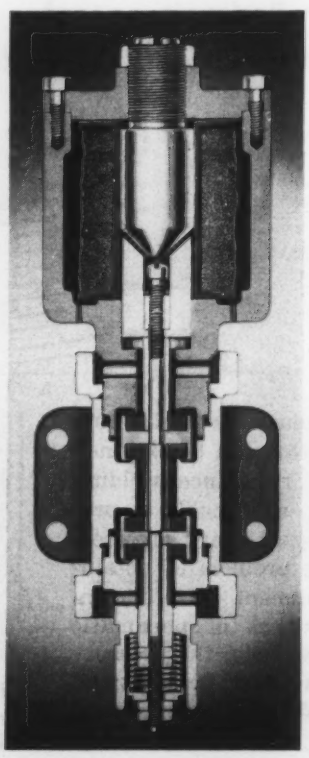


Fig. 2—Above—Cross section of Sciaky booster showing details and mounted electrovalve

Fig. 3—Right—Cross section details of the electrovalve used to control air to the booster



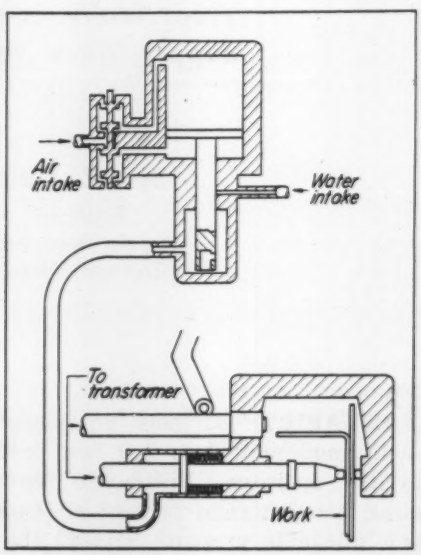
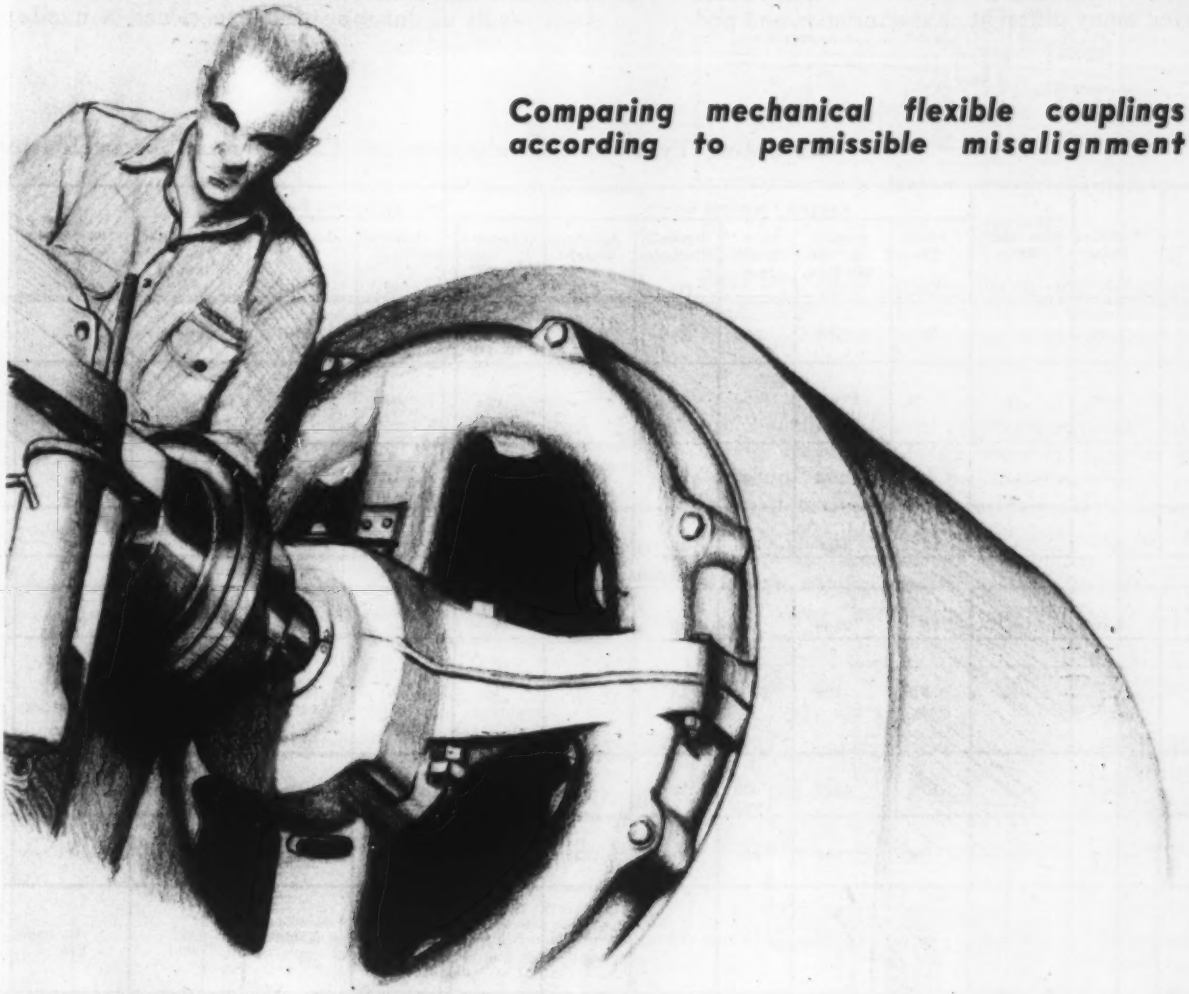


Fig. 4—Schematic diagram showing how booster functions to provide high pressures to welding gun. In rest position, air is admitted to underside of piston, withdrawing plunger from hydraulic chamber. Spring in gun retracts electrode

Selecting Flexible Couplings

Comparing mechanical flexible couplings according to permissible misalignment



By A. F. Gagne Jr.
Mechanical Development Engineer
Fayson Lakes, N. J.

WHEN direct drives and gear reducers first came into common use, designers were plagued by maintenance problems caused by the rigid couplings used with line-shafting. They wanted the close-coupled drive for its compactness, efficiency, and absence of overhung loads, but found that any misalignment produced a multitude of ills: Noise and vibration, serious loss of power, rapid wear or even seizure of shaft in bearings and packings, damage to gears, and fatigue failures of shafting. Yet the most careful alignment at installation or through-boring of all bearings before

assembly was not always adequate; trouble was apt to develop in time because of such factors as thermal expansion, wear, deflection under load, foundation settling, and loosening of bolts.

The flexible coupling already invented for marine propulsion was of course the answer, when modified to suit the new conditions. Over the years new types were developed, until today there is an astonishing variety having many different characteristics and providing special features suitable for almost any application such as flywheel adapter, brake drum, shear pin, clutching, vibration-damping, and thrust.

In making a selection to meet a given drive need, *Fig.* 1, type and amount of flexibility required should be the first characteristic to be considered. The lack of quantitative information in catalogs, however, often causes difficulty.

As a result of unhappy past experience, a number

Coupling Types and Characteristics—Comparisons According to Permiss

Coupling Type	Relative Price	Smallest Std. Shaft Size (in.)	Largest Standard Size††					Max. Deflection, Largest Size				Will carry some cross load for 3 Brg. constr.†	Need for Lubrication	
			Shaft Size (in.)	Capacity* at 100 Rpm (hp)	Max. Speed (rpm)	Overall Diameter (in.)	Approx. Weight (lb)	Long.‡ (in.)	Angular (deg.)	Lateral** (in.)	Torsional (Full load)§ (deg.)			
Thomas Flex. metal disk	Low	1	13	2760	900	34⅜	3200	⅛ SE ¼ DE	½ SE 1 DE	0-SE 0.075 DE	0	SE Yes	None	
Toothed jaw	Low	3/16	½	Fractional	1800	1	....	1/16	10	0.015 (Av.)	3 Backlash (Av.)	Light Load Only	None	
Oldham tongued slider	Very Low	1	6	270	100	14	570	½	1	¼	0	No	Yes	
American jaw flange	Low	½	13	2480	500	30	3200	1	3	1	0	No	Yes	
Torsional Flexibility														
Ajax cushioned pin	Low	⅞	15	1700	840	32	3000	½	½	0.060		Yes	None	
Nonmetallic disk lug type	Low	¼	5½	120	1000	18	325	⅛	½ (est)	0.030 (est)	⅛+⅛ backlash (est)	No	None	
Nonmetallic disk bolted	Low	⅞	13½	1745	900 (est)	32	....	⅛	2	1/16	¼ (est)	Yes	None	
Nonmetallic biscuit (Lovejoy)	Low	½	8½	806	900	21½	1223	⅛	1	0.030	⅛+⅛ backlash	No	None	
Gear coupling	Low	1½	32	61,800	200	78	40,300	1 DE	½ DE	1/16 DE	⅛ (est)	SE Yes	Yes	
Roller chain	Very Low	¾	12	186	900	20	308	⅛	½	0.015	½+1 backlash (est)	No	Yes	
Silent chain	Very Low	½	7½	653	500	20¾	....	⅛ (est)	1 (est)	0.030 (est)	1+1 backlash (est)		Yes	
High Torsional Flexibility														
Bonded rubber, HP style	Low	3/16	1	1/20	14000	2	....	1/32	2	0.030	15	Light Load Only	None	
Inflated rubber gland	Mod.	1¼	17	6000	800	96	7200	¼ (est)	1	0.045 (est)	0.225	No	None	
Rubber biscuit spider	Low	¼	3	13.8	4000	10	48	1/16	5	0.030	3	Yes	None	
Steel spring grid	Low	1	12	2200	1100	35½	3208	1/16	0.9	0.060	1	No	Yes	
Cantilever	Low	½	11	1500	540	32	1815	¼	5	0.030	4	No	Yes	
Franke	Low	1	13¼	3850	490	37	4000	½	..	....	..	No	Yes	

Note: Estimates are those of the writer and are used where full information was not available from the manufacturer.
SE = Single Engagement.
DE = Double Engagement.
* Subject to service factors.
** In establishing installation limits, allow 200% margin for lateral misalignment occurring in service, more for high speeds and loads. The proper values for small sizes will be somewhat less than shown here, but will be double or quadruple when expressed as per cent of shaft diameter.
†† Most manufacturers are prepared to supply couplings larger than the maximum size shown.

of long-established manufacturers are reluctant to reveal data on permissible misalignments even when this is available. They want the user to supply the "best possible" alignment at installation, thus providing for unavoidable future drifts caused by wear, foundation settling, and the other disturbing factors earlier mentioned. Also, they fear that if the mechanic knows a certain amount of misalignment is permissible, he may take liberties—given an inch,

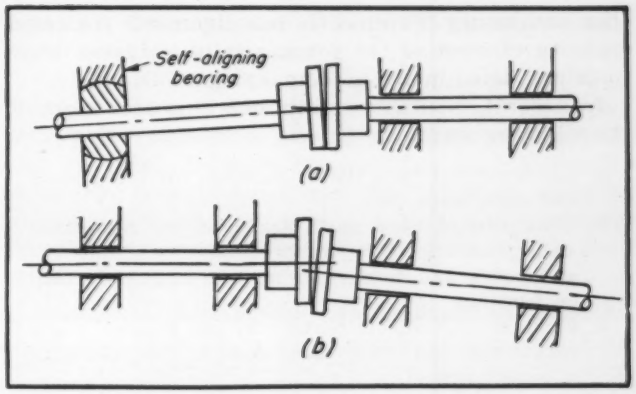
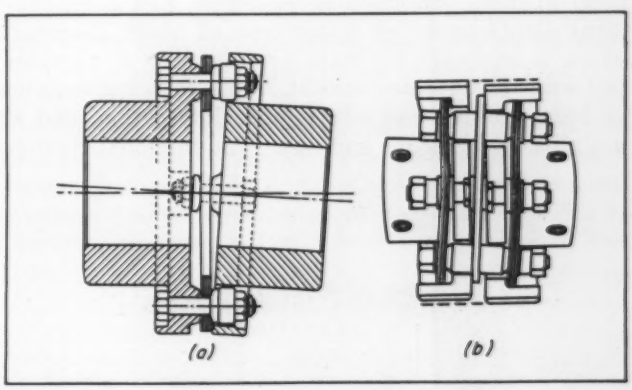


Fig. 1 — Above — Flexible coupling requirements depend upon number of bearings on each shaft. At (a) is shown three-bearing construction using one self-aligning bearing. In four-bearing construction at (b) coupling has both angular and lateral misalignment

Fig. 2—Below—Thomas single-engagement, laminated metal-ring coupling, at (a), showing angular misalignment. Coupling is designed for the three-bearing construction in Fig. 1 and is suitable for heavy-duty high-speed applications. Double-engagement coupling at (b) is manufactured by Thomas Flexible Coupling Co. Drawing shows a lateral misalignment condition of coupling designed for the four-bearing construction in Fig. 1



take a mile—and turn out a sloppy job that will become a maintenance headache.

Those manufacturers making couplings capable of operating effectively with comparatively large amounts of misalignment, are less affected by such problems and hence usually supply such information freely. However, since a requirement for "the best possible" alignment would these days involve optical flats and Invar parallels, the time has come to provide the designer with quantitative information on all couplings. In turn, the designer should provide the shop with specific installation tolerances, just as we no longer write "bores to be perfectly concentric" or "edges to be perfectly straight and square" on a drawing, specify—and obtain—the required accuracy and no more. Any other procedure is apt to waste

issible Misalignment

	Remarks	Manufacturers
	S.E. will support heavy cross load. Withstands dirt, high temps.	Thomas Flexible Coupling Co.
	Very light duty	Boston Gear Works
	Heavy duty; low speed only	Link-Belt, Palmer-Bee, Phila. Gear, Foote Bros. Gear Co., W. A. Jones Co., D. O. James Co., Jeffrey M'f'g. Co.
	Brg. strips replaceable if abused	American Flexible Coupling Co., Phila. Gear, D. O. James
	None	Ajax Flexible Coupling Co., Westinghouse, Medart Co., Phila. Gear, Foote Bros., De Laval
	Infrequent separator replacement required	Lovejoy Flex Coupling Co., Climax Flex. Coupling Co., W. A. Jones, Boston Gear Works, Charles Bond Co., Goodrich Co., Congress Die Casting Co., Central Die Casting Co., Link-Belt, Foote Bros., Dodge Mfg. Co., T. B. Wood Sons, Certified Flex. Couplings, Jeffrey Mfg. Co.
	Withstands dirt and wet	B. F. Goodrich Co., Phila. Gear
	Infrequent cushion replacement required	Lovejoy Flex. Coupling Co., Crocker Wheeler Electric Co.
	High load, speed	Koppers Co., Continental Diamond Fibre Co., Poole Foundry Mach. Co., Farrel-Birmingham Co., Phila. Gear, Dykman Mfg. Co., John Waldron Corp., Amer. Flex. Coupling Co., Universal Gear Corp., D. O. James, De Laval, Westinghouse
	Light loads, moderate speeds	Link-Belt, Cullman Wheel Co., Whitney Chain Co., Morse Chain Co., Diamond Chain Co., Chain Belt Co., Union Chain Co., Ramsey Chain Co.
	Moderate loads, high speeds	Morse Chain Co., Ramsey Chain Co.
	High speeds, small sizes	Lord Mfg. Co., Guardian Products Corp., Climax Flex. Coupling Co.
	Can have clutching action High damping characteristics	Falk, Fawick Airflex Co.
	Withstands dirt and wet	Morse Chain Co., Thompson Products Inc., Lord Mfg. Co.
	High capacity	Falk, Westinghouse
		Brown Eng. Co.
		John Waldron Co., Smith & Serrell, Phila. Gear Co.

‡ Standard Values. More endplay accommodation can usually be provided where needed.
† Refers to the standard construction. Any coupling can be made to support a lateral load by piloting and usually can be so obtained.
§ Backlash will be greater than shown for the smaller sizes.

time and money. Permissible misalignments for rated capacity of most of the commercially available couplings are listed in the accompanying table.

In general, flexibility is attained in one or more of the following ways:

1. Loosely-fitted hard parts: Suitable for low speeds and light loads only
2. Closely-fitted hard parts arranged for lubricated sliding action: This construction is suitable for all speeds and loads and induces negligible load on bearings
3. Flexible or resilient parts: Do not require lubrication but will place some load on the bearings if misaligned.

There are several different kinds of flexibility, all of which have their uses singly or in combination:

LONGITUDINAL FLEXIBILITY: This is usually necessary in small amounts to accommodate thermal expansion and motor end play. Such flexing action is found in most flexible-coupling designs. When considerable slip action is required, a feather key or spline offers a ready solution.

ANGULAR FLEXIBILITY: *Fig. 2a* illustrates a single-engagement Thomas coupling, used effectively between two bearings of a combination of three bearings in line, for example, a fan motor and a self-aligning outboard bearing on the far side of the fan. The coupling's laminated metal ring permits a maximum angular deflection of ½-degree and a longitudinal displacement of 1 per cent of shaft diameter, which is adequate for most purposes, yet it provides full support for rotor weight. This coupling is quiet at high speeds, does not require lubrication, and is not affected by grime and wet. The torsional rigidity of the coupling adapts it to closely-timed drives.

The combination of three bearings and a single-engagement coupling can often be used at an attractive cost and weight saving over the conventional four-bearing construction when perfect angular positioning is not required of one shaft, for example, when a reducer shaft must be extended for several sprockets or pulleys. Such a combination would normally be inadmissible, however, if it were desired to place a crank or gear at the same shaft extension.

The double-engagement Thomas coupling, which consists of two flexible rings bolted compactly to a central spider, is available when lateral flexibility is indicated, as discussed below. *Fig. 2b* shows the operating principle of this type.

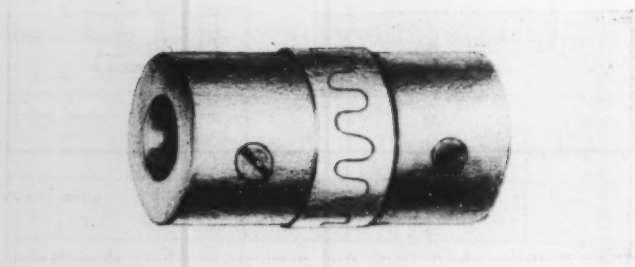


Fig. 3—Above—Toothed-jaw coupling, built by Boston Gear Works, is suitable for light duty. Halves must be slightly separated for flexibility

Fig. 4—Below—Exploded view of Oldham coupling made by Link-Belt Co. for heavy loads and low speeds

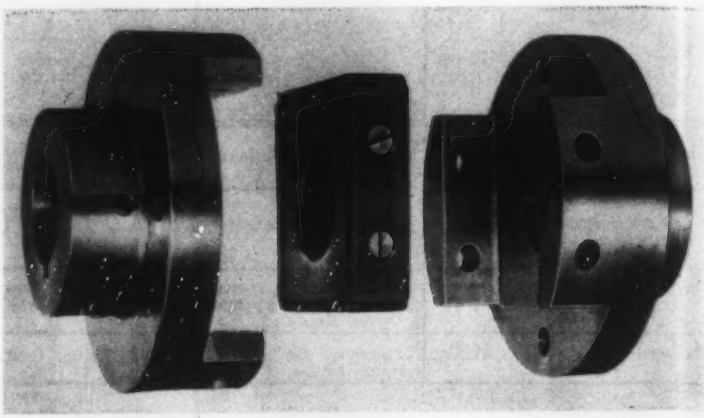


Fig. 5—Exploded view of jaw-flange flexible coupling designed by American Flexible Coupling Co. for heavy loads at standard motor speeds

LATERAL OR PARALLEL FLEXIBILITY: In addition to angular flexibility lateral or parallel flexibility is required when connecting two shafts, each supported in a pair of bearings (see *Fig. 1*). On lightly-loaded shafts under one inch in diameter and operating at speeds under 100 rpm, adequate lateral and angular throw can be secured at minimum cost by a loose-fitting square joint in the shaft ends or by a standard jaw clutch made with considerable clearance. A loose tongue and groove joint is used effectively in glue roll drives, where quick disassembly is necessary for cleaning. Lubrication is not required in these small sizes. *Fig. 3* illustrates a toothed-jaw coupling made in sizes from 3/16 to ½-inch and suitable for small drives and hand-operated mechanisms.

The well-known Oldham coupling, *Fig. 4*, eliminates the need for large clearances and the resultant backlash by providing a double-tongued central slider fitting between two flanges slotted at right angles to each other. It allows considerable end play and is particularly adapted to operating with large amounts of lateral misalignment, up to 5 per cent of shaft diameter. Angular misalignment, however, should be kept below 1 degree. The coupling is often favored for speeds under 100 rpm and for heavy loads up to

the full shaft capacity, as in connecting a gear reducer to the driven machine. Lubrication is required, and the coupling must be protected from grit and dirt. Each shaft must be supported by a bearing near the coupling.

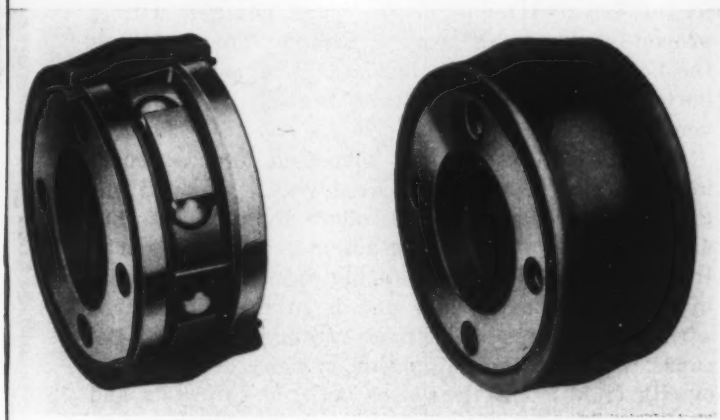
A modern development of the Oldham coupling is the American flexible coupling illustrated in *Fig.* 5. Its large, well-lubricated bearing areas make it adaptable to general-purpose work at speeds up to those of standard motors. Torque is transmitted by C-shaped jaw flanges through a square, sliding center member which has surfaces of replaceable bearing strips lubricated from a reservoir within. This coupling will compensate for misalignments as high as 10 per cent lateral and 3-degrees angular without inducing reactionary stresses in the shafts and bearings but, for maximum life, should be accurately aligned at installation, like most other couplings. When the coupling is abused by excessive misalignment such as might appear after operating some time, all wear is taken by replaceable bearing strips.

An antifriction flexible coupling, suitable for speeds to 5000 rpm and loads to 150 hp, has recently been brought on the market. Made by the Gear Grinding Machine Co., it is comparable to their Rzeppa constant velocity universal joint. As shown in *Fig.* 6 it consists of ground steel balls rolling without backlash between tracked flanges. A flexible synthetic boot is used over the working parts to retain lubricant and seal out dirt and moisture. Maximum permissible lateral misalignment is ⅛-inch, angular 3 degrees.

TORSIONAL RESILIENCE: In addition to misalignment compensation, a small degree of torsional flexibility is often desirable in a high-speed flexible coupling in order to lessen vibration and noise as well as to prevent transmission of starting and running shocks to the motor or gear reducer. This is provided in different amounts by a wide variety of couplings based on the fundamental construction of two flanges connected by resilient spring or nonmetallic elements. The Ajax type, *Fig.* 7, cushions by means of alloy steel pins bolted alternately to each flange and sliding in self-lubricated bronze bushings rubber-cushioned in the opposite flange. The manufacturer recommends limiting total misalignment to ½-degree angular and 0.5 per cent lateral in order to prevent undue heating of the rubber cushions. Torsional deflection under full load is ¼-degree.

Such constructions permit free axial movement to accommodate motor end-play and are especially suited to damping shock and momentary overload. They also afford electrical insulation, thus preventing shaft currents causing electrolysis in direct motor-driven pumps and producing etching or pitting in bearings.

Variations made by a number of manufacturers provide alternate pins or lugs on the face of each flange, fitting loosely in a leather or preferably composition disk or cross so as to place this material in compression, *Fig.* 8. A recent check made at the



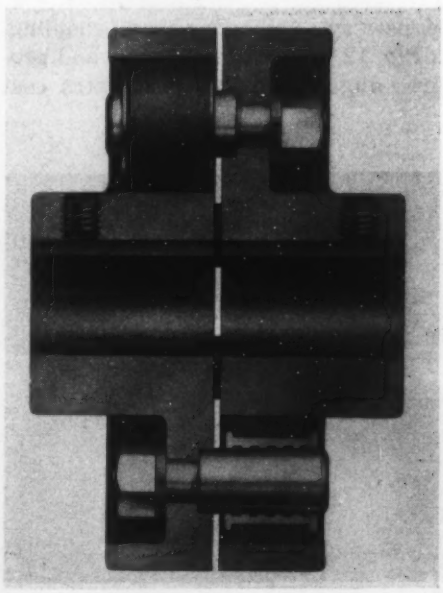
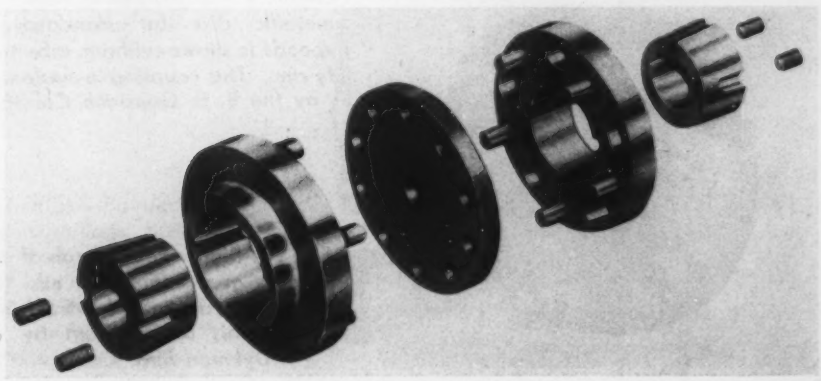


Fig. 6—Left Above—Ballflex antifriction coupling. Built by Gear Grinding Machine Co. in sizes up to 150 hp at 5000 rpm

Fig. 7—Left—Cutaway view of coupling manufactured by Ajax Flexible Coupling Co., being vibration insulating as well as self-lubricating

Fig. 8—Below—Exploded view of nonmetallic disk coupling with pin flanges. This Dodge Mfg. Co. coupling has a new taper-lock quick-installation hub



Power Show in New York City showed this type to be by far the most popular for the typical fractional-horsepower drive. This style requires no lubrication and in many years of service has been found reasonably trouble-free, but the driving and driven members should be aligned carefully to minimize disk replacements. In case of disk failure, the lugs will drive each other direct for an emergency period.

This emergency safety is not found in the Grundy construction, an inversion of *Fig.* 8 in which leather lugs are riveted on a central leather disk to ride in cored pockets in the hubs. *Fig.* 9 shows a bolted disk construction (rubberized fabric) which avoids the backlash of the previous designs and is unaffected by dirt, grit, or moisture.

The nonmetallic material is sometimes used in the form of replaceable cushions or plugs in pockets, a construction permitting brake lining for shock leads at low speeds and high temperatures, leather for sustained loads, and armored rubber for high flexibility, high speeds, and chemicals or wet conditions. In case of cushion failure, such couplings continue to drive, but give audible warning.

In still other types, an endless leather belt is interwoven between flange pins, or tangential leather links carry the load across flange bolts. These were once very common, but are now seldom used because they will not withstand shocks and overloads.

Used for Heavy-Duty Drives

The gear-type coupling is coming into increasing prominence through recognition of its suitability for high-speed heavy-duty geared drives and low cost per horsepower transmitted. There are two basic types, the curvic, or face-gear type; and the more common external-internal gear. As made by most manufacturers, the latter consists of a spur gear on one hub free to slide axially in a mating internal gear on the other hub. Most types are all-metal and require lubrication, but a light, inexpensive, dry coupling, available in small sizes, is made with a laminated phenolic internal gear (Continental Diamond Fibre Co.). In the typical gear coupling, a free rocking action of ¼ to ½-degree is secured for axial shaft misalignment by spherically crowning the hub before cutting teeth and by providing extra clearance between teeth. When lateral misalignment must also be accommodated, as is usually the case, the double-engagement style is specified. *Fig.* 10 illustrates a premium coupling constructed to accommodate 2-degree angularity at each end, for a permissible total of 4 degrees. This is accomplished without excessive clearance and backlash by curving the gear teeth for a spherical pitch-line locus.

In most of these couplings lubrication is provided by a two-piece dust and grit-proof casing filled with heavy oil distributed to all teeth by centrifugal force. The large area of lubricated surface cushions shock to some extent and permits quiet high-speed operation. (In disassembling this coupling, the lapped seal faces should be handled with care).

High-Temperature Applications

Gear couplings have been commonly specified for paper mills, jordans, and rolling mills, but are being selected for an increasing number of general-purpose jobs. Being all-metal, they are suitable for service at elevated temperatures when charged with a proper lubricant and properly sealed. They are built for horizontal operation ordinarily, but suitable supports and lubricant retainers can be designed for vertical operation.

Chain couplings offer a somewhat greater cushioning action, which is secured partly through the grease trapped between the rollers and sprockets but also through a slight spring action in the chain parts. It is assembled from two facing sprockets connected by roller or silent chain and is preferably covered with a protective and grease-retaining shield. Because the lateral misalignment capacity derives principally from small clearances between sprockets and chain, such couplings require careful alignment to prevent excessive motion and wear. Somewhat less careful alignment is needed for a silent-chain coupling because of the many small parts and joints, *Fig.* 11. A relatively new type of roller-chain coupling, the Baldwin-Rex, *Fig.* 12, minimizes backlash and provides 3 to 6-degree angular flexibility at extra cost

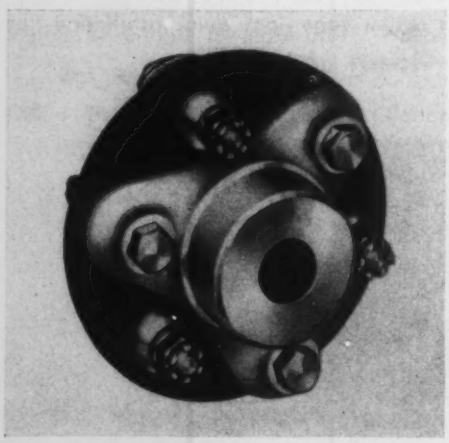


Fig. 9—Left—Climax flexible coupling, using a bolted nonmetallic disk for standard speeds is shown without safety rim. This coupling is made by the B. F. Goodrich Co.

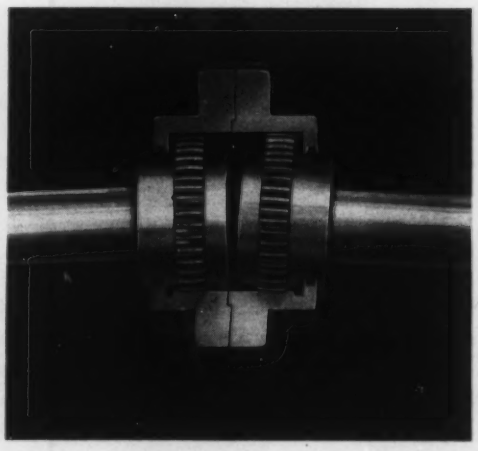


Fig. 10—Right—Photograph of Barcus gear coupling misaligned 2 degrees for each shaft. This unit is built by Dykman Mfg. Co.

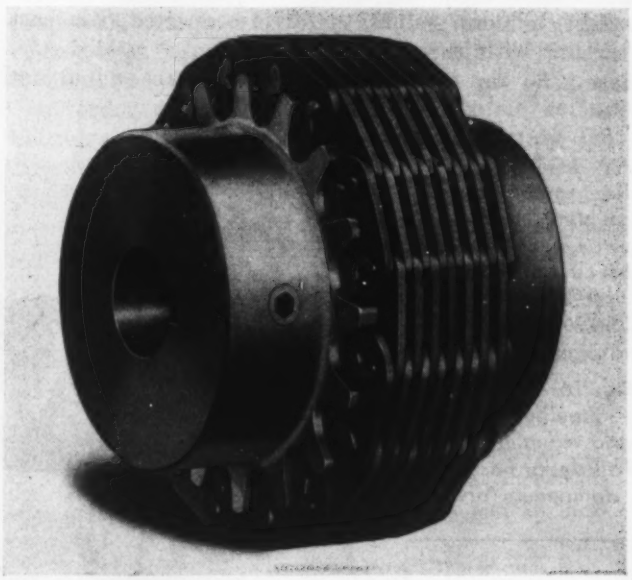
through the use of spherical rollers on one or both sprockets. In general, because of backlash, chain couplings are not ordinarily advisable for reversing torque service or high-speed spur-gear drives, but are typically suited to fans and centrifugal pumps. Principal advantages are very low-cost, all-steel construction, and ready disconnection which have led to wide use on medium loads, speeds and horsepower.

High torsional flexibility is sometimes necessary to isolate extreme shock loads or vibration. Possible constructions in midget sizes include a flat or coil spring, or a section of rubber hose held to the shafts by hose clamps. A commercial coupling for fractional horsepower sizes is the inexpensive bonded-rubber style, *Fig.* 13*a*. Full-load torsional deflection is 15 degrees, and good lateral and angular flexibility are offered. Very recently the Lord Mfg. Co. has put larger sizes on the market, ranging up to 100 hp at 1750 rpm, *Fig.* 13*b*.

The Airflex coupling consists of an inflated rubber tube or gland fitting inside the driven member as pictured in *Fig.* 14. With a strong damping action and a full-load twist angle ranging from 1 to 2 degrees, depending on inflation, it is well suited to drives, such as high-speed diesel engines and reciprocating pumps and compressors. The readiness with which torsional stiffness may be adjusted is very important since it facilitates securing optimum damping. The coupling may be speedily disconnected by deflating.

Morse's Morflex coupling, *Fig.* 15, secures high flexibility by means of a floating center spider carrying four heavy Neoprene cushions bolted alternately to each flange. Full load twist averages 3 degrees, and maximum permissible angular deflection is 5 degrees. Lateral misalignments less than one per cent of the shaft diameter are carried without excessive bearing loading. The Morflex needs no lubrication and may be operated in oily or grimy conditions at temperatures up to 180 F, hence is well suited for use on portable construction and oil-field equipment.

Fig. 11—Silent chain flexible coupling. Cover is omitted on this low-cost design by Morse Chain Co.



CRITICAL SPEEDS: The ratio of critical speeds must be checked on any coupling having a full-load torsional deflection over one degree, in order to prevent possible damaging resonance. Morse recommends that the natural frequency of the coupling and rotating part system be less than 40 or more than 200 per cent of the exciting frequency. Adjustments can be made if necessary to secure these ratios by selecting a larger coupling to raise the natural system frequency or by using a flywheel or two couplings in tandem to lower it. Auxiliary damping can be provided where the range of operating frequencies is too great. Morse also manufactures a high-damping Radial coupling having a full-load torsional deflection of only one degree, which may be a better choice than the Morflex for installations requiring less misalignment compensation. Sizes range from 1⅜ to 8 inches (262 hp at 100 rpm).

There are several all-metal high-flex types particularly useful for heavy duty or higher temperatures. Flexible shafting is excellent for small sizes; although in larger sizes it is necessary to provide flange-type couplings with some form of multiple

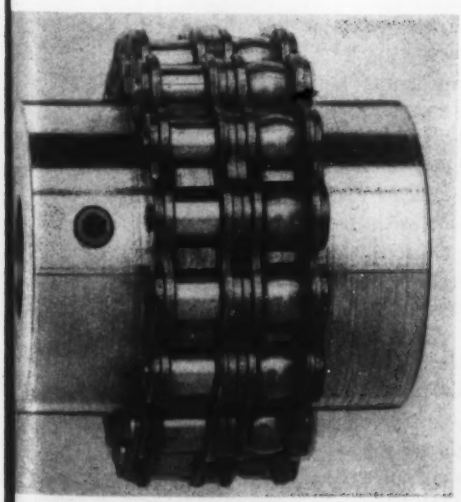


Fig. 12—Left—Baldwin-Rex high-flexibility spherical roll coupling made by Chain Belt Co. This half-spherical, half-straight design will operate successfully at 3-degrees deflections

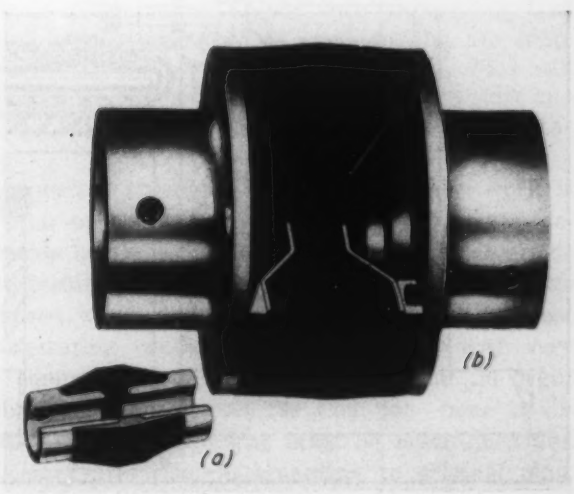


Fig. 13—Right—Bonded-rubber couplings built by the Lord Mfg. Co. At (a) is design for fractional - horsepower sizes. Integral-horsepower-coupling is at (b)

spring connection. The Falk Steelflex coupling, made in sizes up to 72,000 hp at 100 rpm (30-inch shaft) is shown in *Fig.* 16. It is based on a flat steel spring, wound in the form of a grid over specially shaped grooves cut into each hub. A housing is used to retain grease and protect the coupling from grit. Because of its nonlinear spring rate and grease filling, this coupling has good dampening characteristics and is useful in avoiding certain types of tooth chatter, but should be checked for critical speeds. It is interesting to note that this coupling is usually selected by torsional spring rate rather than by bore size. Full load deflection of standard couplings ranges from 2 degrees in some small sizes down to ¼-degree in the largest sizes.

The Kanti-Lever flexible coupling manufactured by the Brown Engineering Co. is a close functional relative of the Steelflex, because leaf springs are constrained in curved slots, giving a nonlinear spring rate, damping, and free end play. Another variation of the leaf spring construction is the Francke, *Fig.* 17, used for many years, but now being discontinued by several manufacturers in favor of other designs. Smith and Serrell now make a modification of the Francke called the Flexpin coupling which should have longer life.

DOUBLE COUPLINGS: When an unusual amount of flexibility is required in all directions, a pair of universal joints is indicated unless torsional resilience or large size is needed. *Fig.* 18 illustrates a stock coupling made by Morse from two standard Morflex couplings. Aside from special circumstances, the normal utility of such couplings is in connection with very flexible structures wherein ordinary couplings would soon be destroyed or destroy the bearings of the connected machines. Rather than reinforce the structure, which would usually be costly and might be too heavy to be practical, the coupling serves as an excellent alternate.

FLOATING SHAFT COUPLINGS: When the double coupling is separated by a long shaft, usually tubular, the floating shaft coupling is produced. This has gained acceptance for machines separated by some feet because it permits considerable lateral misalignment, as is to be expected with the individual machine foundations common under such circumstances. Furthermore, the floating shaft dispenses with the intermediate bearings otherwise needed.

Most coupling types may be applied in this manner, although some require internal pilots to center the floating shaft and prevent whipping. Those particularly adapted are the types normally used in a double-engagement style, such as the laminated disk and gear types, which may be split in half at very little additional cost. They should always be installed with hubs as close as practical to the machine bearings, in order to minmize overhang.

Floating shaft and high-flex couplings permit savings in construction costs, since frames may be made deliberately light and need not be machined. For instance, a motor might be direct-connected to a cast housing with the whole mounted on a welded-steel base. So far conventional, but the base would not

Fig. 14—Below—Airflex coupling, intended for use where pulsating torque of drive requires high dampening properties. This unit is designed by Fawick Airflex Co.

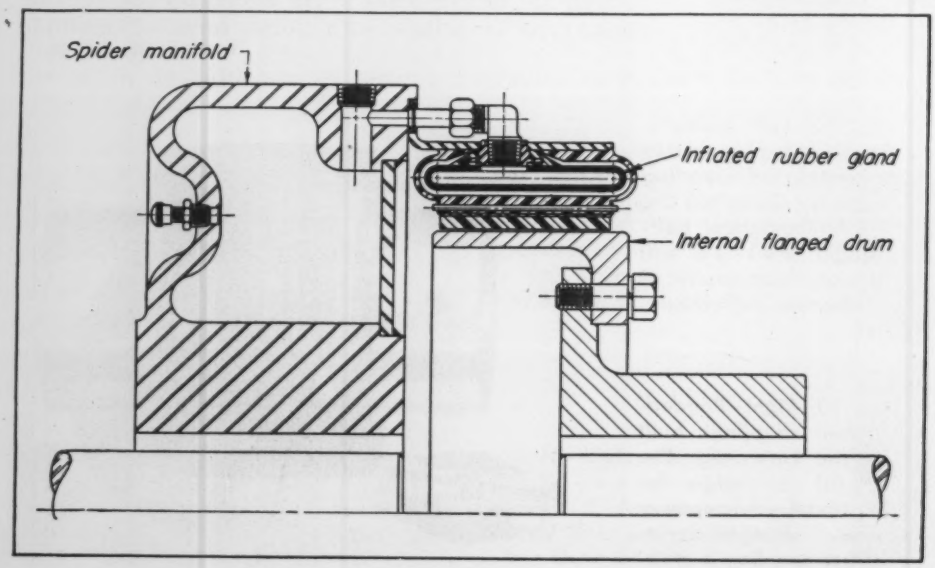


Fig. 15—Right—Morflex oval-flange coupling, with cutaway view of rubber biscuit. Manufactured by Morse Chain Co., unit has high flexibility

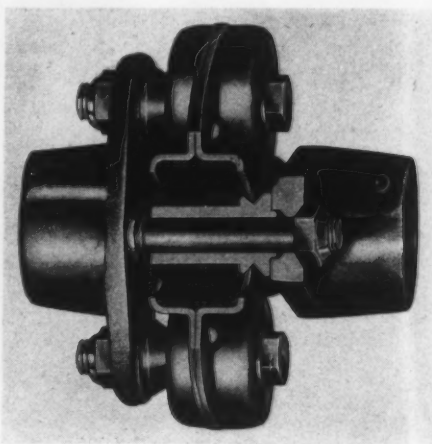
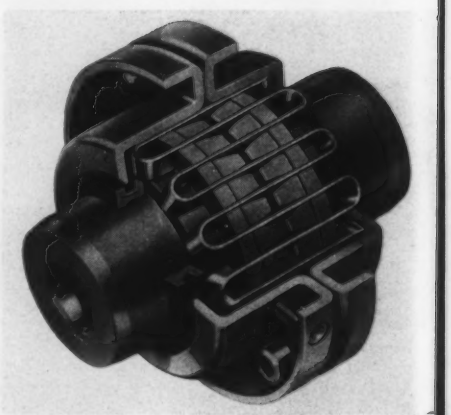


Fig. 16—Right Below — Steelflex spring-grid coupling. This Falk design has strong dampening action



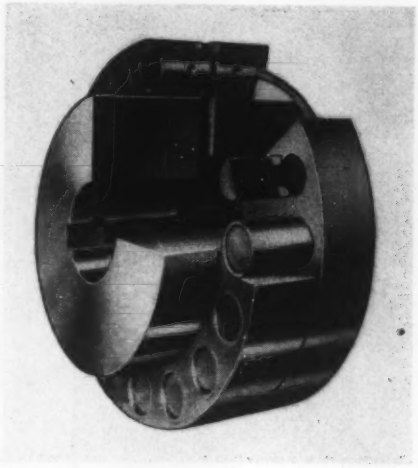


Fig. 17—Left — Francke Flexpin coupling made by John Waldron Corp. One end of flexible laminated pin is held by a spring retaining ring, the other is free to slide in a bushing

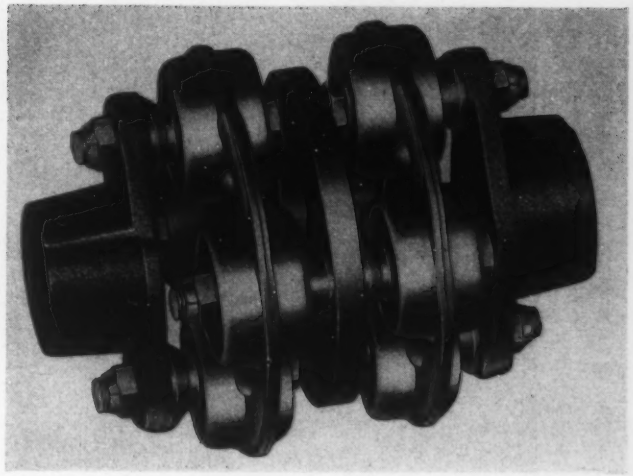


Fig. 18—Right — Moreflex double coupling is made in the same capacities as the standard coupling shown in Fig. 15, but is capable of increased deflection

be stress relieved and neither it nor the cast housing would be planed. No welded pads would be provided, the units being mounted direct on the plate or structural steel members. Naturally, these suggestions presuppose the application of precautions such as proper clamping or jigging plus tack welding for accuracy, together with interrupted welding (electric) to minimize distortion.

In order to prevent distortion of frame or light housings and gear cases when the mounting bolts are drawn up tight, shims would be supplied as determined by feeler gages inserted at contact points before bolting. A possible alternate would be the three-point support favored in some engine mountings.

SELECTION FACTORS: The following factors should be checked in addition to the usual considerations of cost, flexibility, size, weight, and limiting speed for a coupling of adequate capacity:

1. *Special requirements:* Considerations such as frequent disengagement, high end-float, thrust or lateral support, quietness, and electrical insulation.
2. *Replacement cost:* In case of abuse, can an inexpensive part be replaced?
3. *Torsional stiffness or flexibility:* Check on advantages of vibration isolation vs. possibilities of critical speeds.
4. *Backlash:* Not to be permitted in a high-speed reversing drive or a spur gear drive.
5. *Accessibility:* Most couplings must be accessible for inspection, lubrication, or replacement of parts.
6. *Service conditions:* Will the coupling operate satisfactorily when wet, oily, dirty, hot, or cold as the case may be? Is the coupling suited to shock loads and is there a sufficient margin of flexibility for probable alignment drifts?
7. *Means of installation:* Light machinery—coupling types with spring resistance to lateral deflection aid line-up at assembly. Heavy machinery—it should be possible to lower the machinery directly into place and then assemble the coupling.
8. *Safe failure:* Will the coupling warn of excessive misalignment or approaching failure (as by a buzzing noise), and will it continue driving?

In selecting flexible couplings, it must be borne in mind that most types are of limited flexibility and, accordingly, they or the machine bearings will suffer damage or rapid wear if due care is not taken at installation to assure an alignment well within the limits recommended by the manufacturer. In general, good practice on ordinary couplings has been considered a lateral alignment within 0.002 to 0.004-inch for high-speed drives, as turbines, and within 0.01-inch for low-speed drives. Wear is approximately proportional to load as well as to speed, and this should be taken into consideration along with hours per day of operation. Also, reasonable wear rates are often permissible when replacement of the wear element is possible.

Careful installation allows for the inevitable changes which occur with service. However, it is advisable to check alignment periodically, which is readily accomplished with a straight edge laid along the coupling halves at several points around the periphery. Misalignment should be corrected if it becomes greater than the manufacturer's recommendation. It is particularly important to check the clearance between flanges also because, should flanges hit at any point, the coupling will be noisy and its flexing action will be cramped. If axial hunting of a motor armature is noticed with a coupling type offering spring resistance to axial motion, the coupling hubs should be reset on the shafts. This will enable proper magnetic centering of the armature and stop the sometimes dangerous hunting action of the motor.

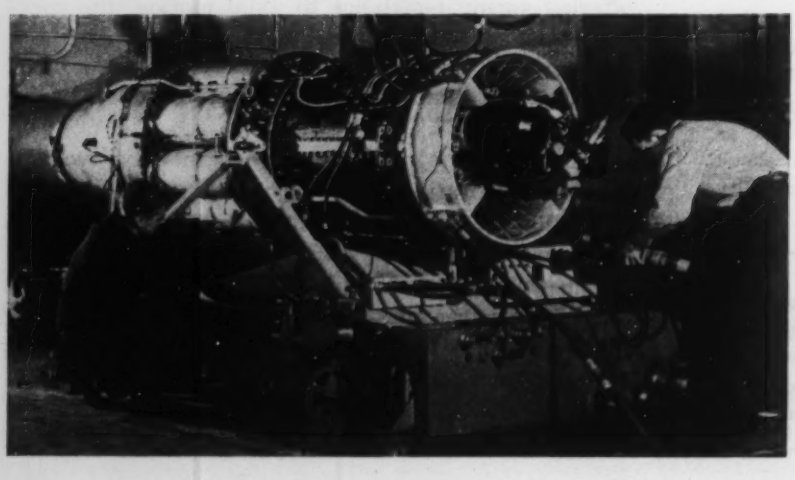
A principal objective in any engineering work is minimum operating cost, which includes power, depreciation on the investment, and maintenance of the entire installation. A standard flexible coupling can be chosen which will give satisfaction under almost any operating condition and which will cost very little compared to the units coupled. But the right coupling must be selected for each job—none is all-purpose—and this coupling must be maintained and if necessary, lubricated, according to original plan.

New Jet Engine Develops Increased Thrust

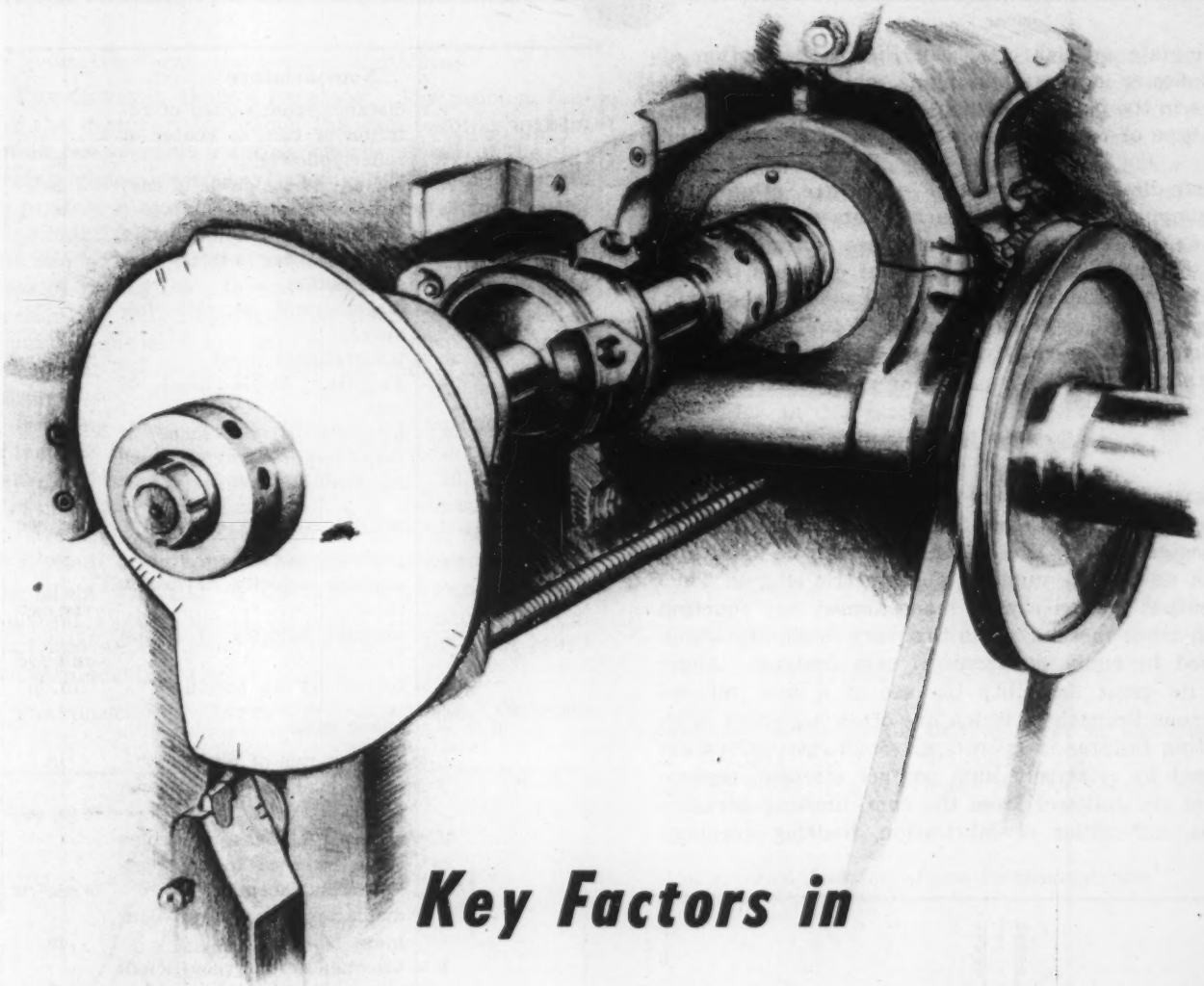
NORTH American's B-45, one of the Air Force's newest bombers, is powered by four J-47 (TG-190) turbojet engines and has a rated speed of 550 miles per hour. These engines also power the Air Force's penetration fighter which recently set an official world speed record of 670.981 miles an hour.

Designed and built by General Electric, the J-47 engine develops over 5000 pounds thrust, representing more than a three-fold increase in thrust power over the first Air Force jets flown in 1942. Comparison of thrust developed by jet engines with the horsepower of reciprocating engines shows that one pound of thrust is equivalent to one horsepower at 375 miles per hour, but at twice this speed one pound of thrust approximates two horsepower. Appearing similar and weighing approximately the same as the J-35 jet powerplant, the J-47 has multiple combustion chambers and an axial flow turbine, and can burn either kerosene or grade 100/130 gasoline. During normal operation, air at the rate of 90 pounds per second is delivered by the engine's 12-stage compressor into the combustion chambers.

Shown below in a test cell at General Electric's new Lockland plant, the engine measures about three feet in diameter. Increased thrust of the engine has been obtained over previous models without any corresponding increase in specific fuel consumption. With the engine operating at a normal continuous cruise thrustpower, exhaust temperatures are so high that special high-temperature-resistant alloys have been incorporated in the combustion chambers, nozzle diaphragm, turbine wheel, and exhaust system. The engine is lubricated through a pressure feed and return oil system to bearings and accessory gears. Its electrical system employs a direct-drive starter-generator, two igniters and two ignition transformers.



While General Electric will continue to manufacture parts for the J-47 engines built at its Lynn, Mass. plant, production at the Lockland plant will be chiefly engine assembly from component parts, furnished by 120 subcontractors, and engine test. Delivery of the first engines from the Lockland plant was accomplished in less than six months from the date of acquisition of the plant.



Key Factors in Cam Design and Application

By John A. Hrones
Professor of Mechanical Engineering
Massachusetts Institute of Technology

Part I–Basic Relationships

A CAM system is composed of four elements: The drive, the cam, the cam follower, and the driven system. Cam and follower may both move in translation as shown in *Fig.* 1, but more frequently the cam is driven in rotation about a fixed axis with the follower moving in translation, *Fig.* 2. In other instances both the cam and its follower move in rotation, *Fig.* 3.

In the cases pictured in *Figs.* 1, 2 and 3 the motion of points on the cam and its follower takes place in the same or parallel planes. Such cams are

called plate or disk cams. In *Fig.* 4 the motion of the follower occurs in a plane which lies at right angles to the planes in which points on the cam move. This type of cam is known as a barrel or cylindrical cam.

Three-dimensional cams, *Fig.* 5, are often used for computing purposes. Such a cam can be considered as an infinite number of plate cams of nearly zero thickness, all having different contours, rigidly fastened together and rotating about a fixed axis. Different axial sections can actuate the follower depending upon the relative lateral position of the cam and its follower.

System Is Versatile

FLEXIBILITY: The cam-follower mechanism is one of the most versatile and flexible systems available to the designer. The surface of a cam can be made any one of an infinite number of geometric shapes. Thus the output motion can be made almost any function of the input motion. It is this very flexibility which has led to many unsuccessful cam designs. Along with its great flexibility the use of a cam imposes numerous limitations which are often neglected, with resulting failures in operation. Such restrictions are imposed by relatively high contact stresses, separation of the follower from the cam, limiting pressure angles, difficulties of fabrication, limiting accuracy

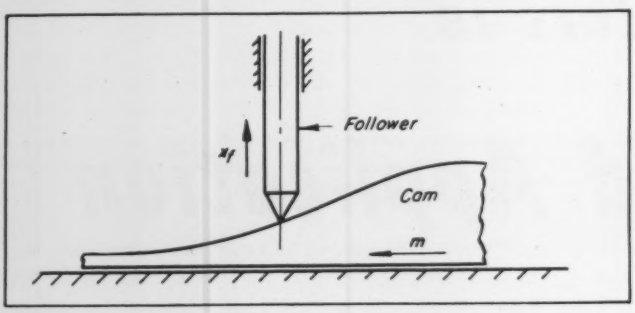


Fig. 1—Above—Cam-follower system. Input (m) is translation; output (x_f) is translation

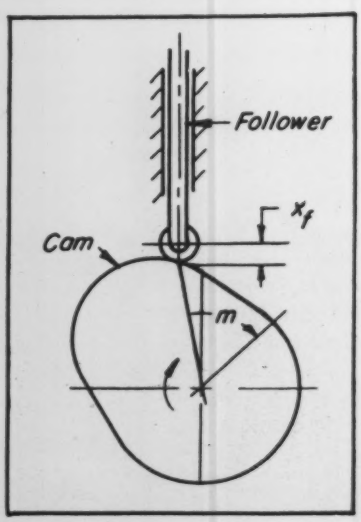


Fig. 2 — Left — Basic cam-follower mechanism. Input (m) is rotation; output (x_f) is translation

Nomenclature

r =	distance from center of rotation of cam to center of roller follower	in.
R =	radius of base circle of cam	in.
ρ =	cam curvature radius	in.
y_0, Z_0 =	y and Z co-ordinates of r when follower is in its lowest position	in.
x_f =	displacement of cam follower	in.
m =	translational input	in.
θ =	angular displacement of cam	rad
θ_0 =	angular displacement of cam required to produce full travel of follower	rad
$\left(\omega = \frac{d\theta}{dt} = \omega_f\right)$ =	angular velocity of cam	rad/sec
ϕ =	pressure angle	rad
ω_d =	angular velocity of driven table	rad/sec
ω_c =	angular velocity of pinion "c"	rad/sec
T_c =	torque driving pinion "c"	in.-lb
$n = \frac{\omega_d}{\omega_c}$ =	speed ratio	
r_c =	pitch radius of pinion "c"	in.
J =	moment of inertia of driven table	lb in. sec^2
M =	equivalent mass of driven table referred to cam follower displacement	lb sec^2/in.
x =	displacement of equivalent mass	in.
b =	viscous-damping coefficient (equivalent mass to cam follower)	lb sec/rad
c =	viscous-damping coefficient (equivalent mass to frame)	lb sec/rad
C =	fatigue factor	
K =	equivalent system stiffness	lb per in.
ζ =	damping ratio (equivalent mass to follower)	
ζ_c =	damping ratio (equivalent mass to frame)	
$\omega_n = \sqrt{\frac{K}{M}}$ =	natural undamped angular frequency of driven system	rad/sec
D =	operator $D = \left(\frac{1}{\omega_n}\right)\frac{d}{dt}$	1/rad
F =	component of force on cam surface in direction of x_f	lb
L =	cam lift	in.
$v_f = \frac{dx_f}{dt}$ =	velocity of follower	in. per sec
$a_f = \frac{d^2x_f}{dt^2}$ =	acceleration of follower	in. per sec^2
$a_g = 4L\left(\frac{\omega_f}{\theta_0}\right)^2$ =	maximum follower acceleration (gravity cam) a_h maximum follower acceleration (harmonic displacement cam)	

of geometric form, and similar limitations.

THE GENERAL DESIGN PROBLEM: The problem facing the designer, for which the cam-follower system offers one possible solution, can be stated in the following general terms. Design a group of elements to produce a motion, x_f, which will bear some desired functional relationship to an input motion, m. A few commonly used output/input functions are shown in *Figs.* 6 through 9. In many cases of slow-speed operation the only important functional relations which must be satisfied are the ratio of output to input motion at the beginning and the end of the output motion.

Indexing the table motion of an automatic machine lies in the latter category. Schematically the cam follower system is shown in *Fig.* 10. The output motion, x_f, is known and it is necessary to synthesize the cam-follower-driven system to produce this result from some available input motion, m. In the great majority of cases the input motion is a constant angular speed, although interesting and unexploited applications exist in which the input speed is continuously varied.

TRANSLATIONAL INPUT—TRANSLATIONAL OUTPUT:

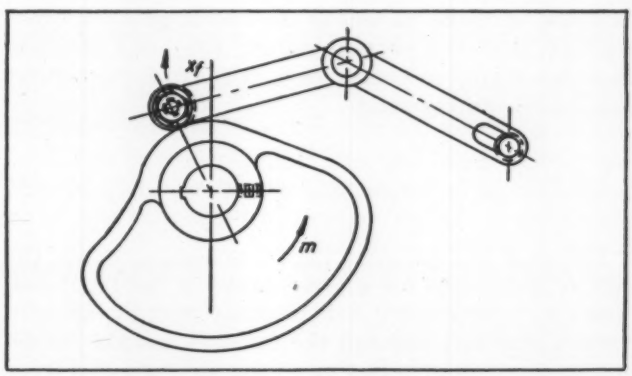


Fig. 3—Above—Cam-follower system. Input (m) is rotation; output (x_f) is rotation

Fig. 4—Below—Cylindrical cam-follower system. Input (m) is rotation; output (x_f) is translation

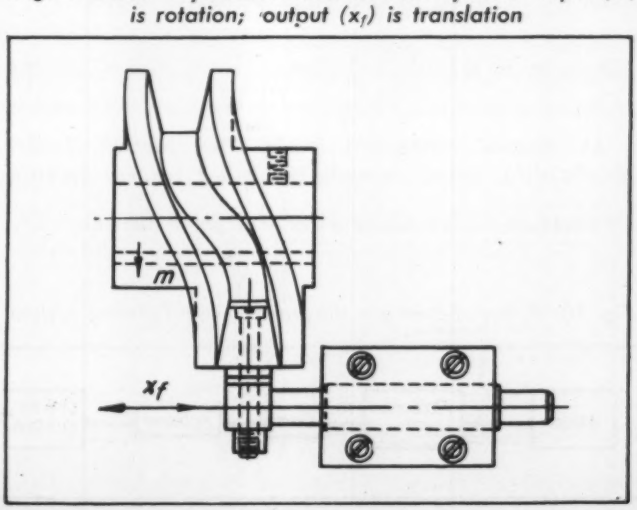


Fig. 11 shows a system in which an input translation, m, causes an output translation in a direction making an angle, α, with the input direction. A pointed follower operating on a plane surface directly drives a mass, M. Such a system, while not a practical design, will serve to illustrate most directly some of the problems common to all cam-follower systems. The amplitude of motion of the follower is called the lift, L. The angle between the normal to the cam surface at the point of contact and the line of motion of the follower is called the pressure angle, ϕ. The minimum distance from the center of rotation of the cam to the cam surface is the base radius, R. In this case $R = \infty$. Isolation of the follower with forces which act upon it leads to some basic relationships, *Fig.* 12:

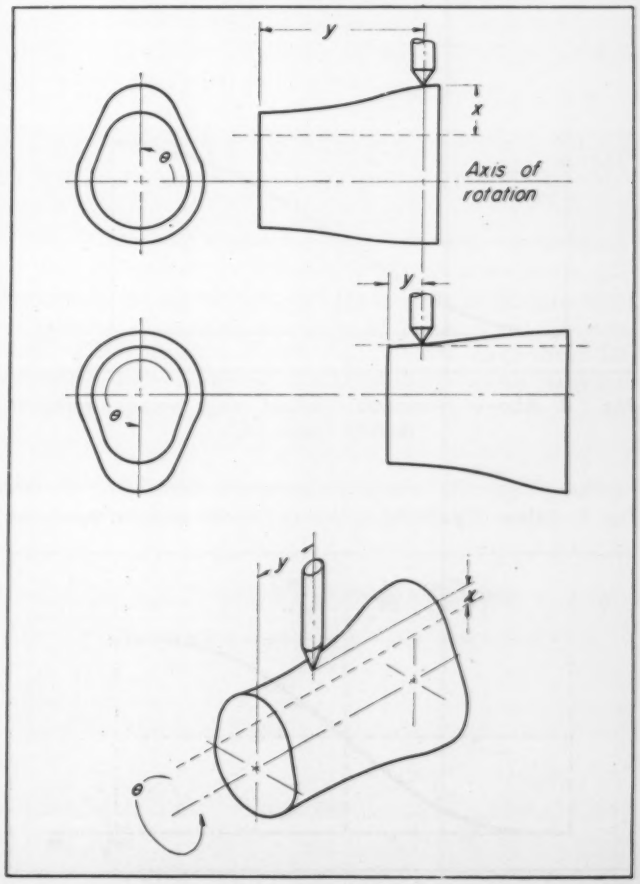
$$F_1 = F_R \cos \phi - f_R F_R \sin \phi - f_2 F_2 \quad \ldots\ldots (1)$$

$$F_2 = F_R \sin \phi + f_R F_R \cos \phi \quad \ldots\ldots (2)$$

$$F_R = \frac{F_1}{(1 - f_2 f_R) \cos \phi - (f_R + f_2) \sin \phi} \quad \ldots\ldots (3)$$

where F_1 is the output driving force or the load on the follower and F_R is the normal force on the cam surface. For a given load, F_1, the lowest normal

Fig. 5—Below—Three-dimensional cam



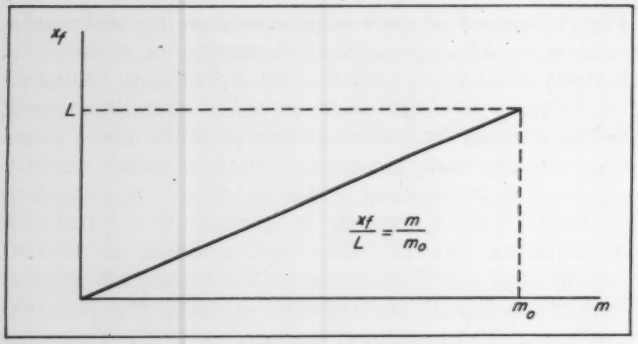
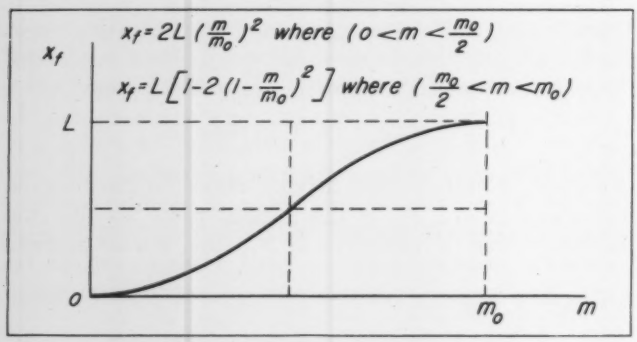


Fig. 6—Above—Uniform motion output (x_f) versus uniform motion input (m)

Fig. 7—Below—Parabolic output (x_f) versus uniform motion input (m)



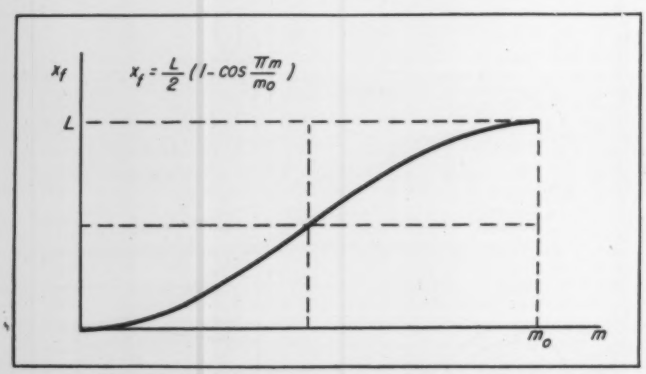
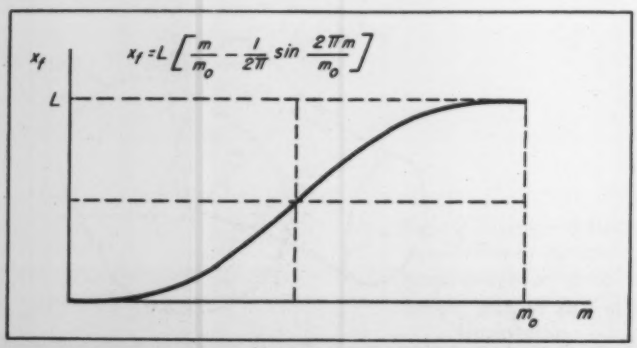


Fig. 8—Above—Harmonic output (x_f) versus uniform motion input (m)

Fig. 9—Below—Cycloidal output (x_f) versus uniform input (m)



force occurs when the pressure angle, ϕ, is zero. When the pressure angle reaches a value such that the denominator of Equation 3 is zero the normal force becomes infinitely large and the cam-follower system becomes inoperative. Such a condition is reached when:

$$\tan \phi = \frac{1 - f_2 f_R}{f_R + f_2} \quad \ldots\ldots (4)$$

For values of $f_R = f_2 = 0.1$, $\phi = 78.5$ degrees.* With normal coefficients of friction, locking is therefore not a serious limitation. As the coefficients of friction approach zero the ratio of the normal force on the cam surface to the load becomes:

$$\frac{F_R}{F_1} = \frac{1}{\cos \phi} \quad \ldots\ldots (5)$$

Therefore, as the pressure angle increases, this force ratio becomes larger, producing higher stresses in the cam and follower and increasing the input cam force F_m. Neglecting friction:

$$F_m = F_1 \tan \phi \quad \ldots\ldots (6)$$

Because of these factors it is considered good practice to limit the pressure angle to thirty degrees. For the simple system shown in *Fig.* 12 the following relationship is valid

$$\tan \phi = \frac{L}{m_o} = \frac{dv}{dm} \quad \ldots\ldots (7)$$

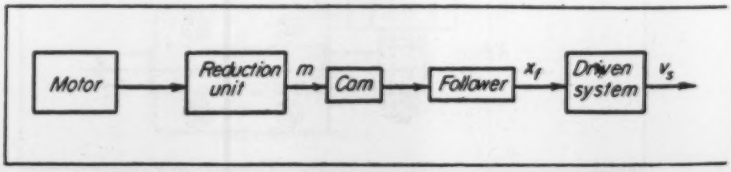
Limiting the pressure angle, therefore, limits the lift, L, obtainable for a given range of the input motion, m_o. This difficulty is often met by using a motion amplifier between the follower and the driven mass. Such an amplifier may take the form of a lever or gearing. Use of a pointed follower will cause very high stresses at the point of contact which would result in a rapid failure of the surfaces. Roller followers are widely used to reduce such stresses. The load, F_1, is found by isolating the driven mass.

$$F_1 - F_L = M\left(\frac{d^2x}{dt^2}\right) + Mg \quad \ldots\ldots (8)$$

At speeds commonly used the inertia force, $M(d^2x/dt^2)$, often exceeds the other forces, making

* When $f_R = f_2 = 0.2$, locking occurs when $\phi \geqq 67$ degrees.

Fig. 10—Below—Schematic diagram of cam-follower system



necessary the introduction of constraints to maintain contact between the cam and the follower. Such constraints take the form of a second surface or a spring.

PRESSURE ANGLE: For the general case of the plate cam shown in *Fig.* 13 the pressure angle, ϕ, is given by the equation

$$\phi = \tan^{-1} \frac{y^2 \frac{dy}{d\theta} - Z_o r^2}{y\left[Z_o \frac{dy}{d\theta} + r^2 \right]} \quad \ldots\ldots (9)$$

The value of the input motion, θ, at which the maximum pressure angle occurs can be obtained from the equation

$$y^2 Z_o \left(\frac{dx_f}{d\theta}\right)^3 - \left(y^4 - Z_o^4\right)\left(\frac{dx_f}{d\theta}\right)^2 + Z_o r^4 \left(\frac{dx_f}{d\theta}\right) + r^4 y \left(\frac{d^2x_f}{d\theta^2}\right) = O \quad \ldots\ldots (10)$$

Approximate values of ϕ_{max} can be found quickly by using the following relationship

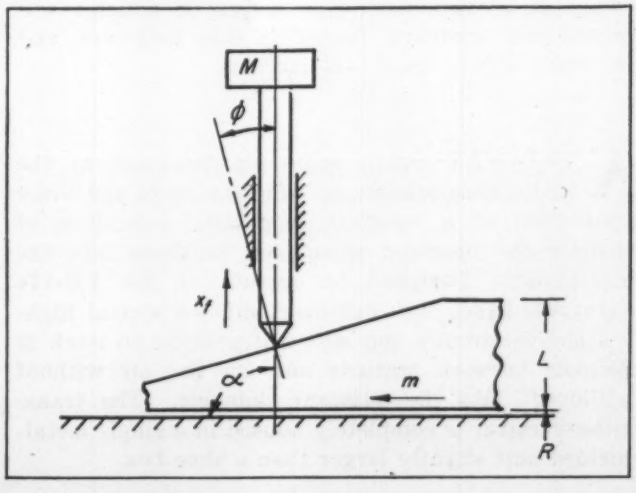
$$\phi_{max} = \tan^{-1} \frac{2}{2R + L} \left(\frac{dx_f}{d\theta}\right)_{max} \quad \ldots\ldots (11)$$

For cams with radial followers ($Z_o = O$) Equation 11 gives exact results.

RADIUS OF CURVATURE: The minimum radius of curvature should be determined as it is necessary for stress calculations. In rectilinear co-ordinates (see *Figs.* 6 to 9) the radius of curvature is given by the equation

$$\rho = \frac{\left[1 + \left(\frac{dv}{dm}\right)^2\right]^{3/2}}{\frac{d^2v}{dm^2}} \quad \ldots\ldots (12)$$

Fig. 11—Simple cam-follower system. L = lift; ϕ = pressure angle; R = radius of base circle



Generally where the radius of curvature is small, values of dx_f/dm are small compared to one. Therefore, the minimum radius of curvature of the pitch surface of the cam is given approximately by the equation

$$\rho_{min} = \frac{1}{\left(\frac{d^2v}{dm^2}\right)_{max}} \quad \ldots\ldots (13)$$

While this relationship has been developed for a cam of infinite base radius it gives good results for values of R/L greater than 2 when used in the following modified form:

$$\frac{1}{\rho_{min}} = \left(\frac{d^2v}{dm^2}\right)_{min} - \frac{1}{R + L} \quad \ldots\ldots (14)$$

For plate cam, input is θ and output is x_f, therefore

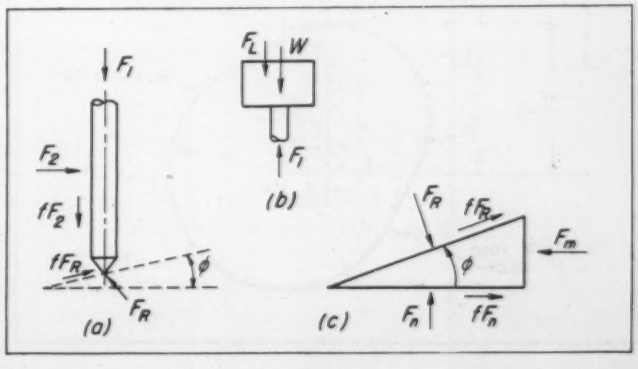
$$\frac{1}{\rho_{min}} = \left(\frac{1}{R + L}\right)^2 \left(\frac{d^2x_f}{d\theta^2}\right)_{min} - \frac{1}{R + L} \quad \ldots\ldots (14a)$$

The minimum radius of curvature given by Equation 14 or 14*a* limits the minimum roller diameter for a closed cam (see *Fig.* 14). ρ_{min} occurs when d^2x_f/dm^2 reaches its peak negative value. For an opened cam in which the follower is spring loaded, the minimum roller diameter is limited by the minimum external radius of curvature, ρ_{cr}, the value of which is approximately given by the following equation for cams with radial followers:

$$\frac{1}{\rho_{cr}} = \frac{1}{R^2}\left(\frac{d^2x_f}{d\theta^2}\right)_{max} - \frac{1}{R} \quad \ldots\ldots (15)$$

The following example illustrates the application of the foregoing relationships: Determine basic dimensions of plate cam to produce a harmonic displacement of the follower. Lift (L) is to be one inch with pressure angle (ϕ_{max}) not exceeding 30 degrees. Lift is to be accomplished in 90 degrees

Fig. 12—(a) Forces acting on follower; (b) forces acting on driven mass; (c) forces acting on cam



rotation of the cam (θ_o) preceded and followed by rest periods.

From Equation 11,

$$\tan \phi_{max} = \frac{2}{2R + L} \left(\frac{dx_f}{d\theta} \right)_{max}$$

But from *Fig.* 8, letting the input be θ and the output x_f,

$$x_f = \frac{L}{2} \left[1 - \cos \frac{\pi\theta}{\theta_o} \right]$$

Differentiating,

$$\frac{dx_f}{d\theta} = \frac{L\pi}{2\theta_o} \sin \frac{\pi\theta}{\theta_o}$$

Therefore

$$\left(\frac{dx_f}{d\theta} \right)_{max} = \frac{L\pi}{2\theta_o} = L$$

and

$$\tan 30° = \frac{2}{2R + 1} \quad (1)$$

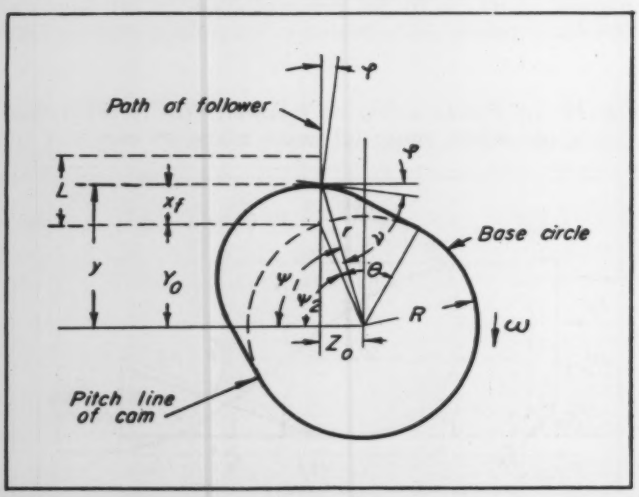
or $R = 1.232$ inches (use $R = 1.250$ inches)

Approximate values of minimum internal and external radii of curvature are determined from Equation 14*a*,

$$\frac{1}{\rho_{min}} = \frac{1}{(R + L)^2} \left(\frac{d^2x_f}{d\theta^2} \right)_{min} - \frac{1}{R + L}$$

From *Fig.* 8, remembering that output is θ and input is x_f,

Fig. 13 Diagram of plate cam, showing pressure angle between cam and follower



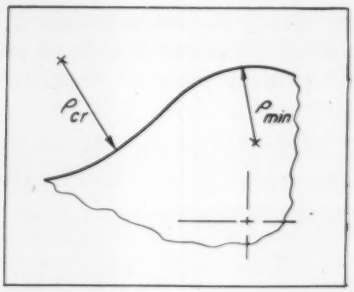


Fig. 14 — Illustrating cam curves which limit follower roller diameter for open and closed cams

$$\frac{d^2x_f}{d\theta^2} = \frac{L}{2} \left(\frac{\pi}{\theta_o} \right)^2 \cos \frac{\pi\theta}{\theta_o}$$

$$\left(\frac{d^2x_f}{d\theta^2} \right)_{min} = -\frac{L}{2} \left(\frac{\pi}{\theta_o} \right)^2 = -2L$$

$$\frac{1}{\rho_{min}} = \frac{-2L}{(1.25+1)^2} - \frac{1}{1.25+1}$$

Therefore,

$$\rho_{min} = -1.2 \text{ inches}$$

Also,

$$\frac{1}{\rho_{cr}} = \frac{1}{R^2} \left(\frac{d^2x_f}{d\theta^2} \right)_{max} - \frac{1}{R}$$

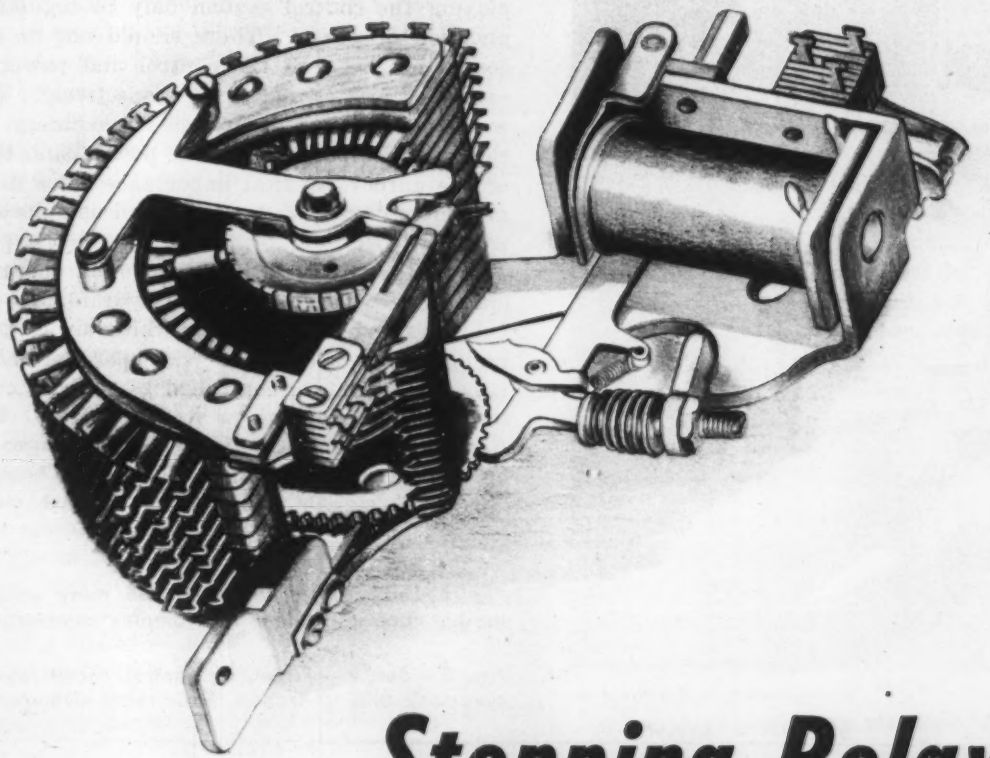
Therefore,

$$\rho_{cr} = 2.08 \text{ inches}$$

By the use of the simple relationships presented, the approximate basic cam dimensions to provide the required lift in the required cam angle can be quickly determined. In general, for a given lift and given active cam angle, large values of pitch radius, R, produce large radii of curvature and small pressure angles; both highly desirable conditions. Where space requirements impose serious limitations it may be desirable to design the cam to have a smaller lift and simplify the follower motion by the use of a lever or other device.

Part II of this three-part series of articles will discuss cam contours, forces on cam followers, and the three widely used cam motions.

A TWO-WAY mobile radio set developed by the Radio Corporation of America locks the voice input level at a constant amplitude, regardless of whether the operator shouts or whispers into the microphone. Designed to operate in the 152-174 megacycle band, the equipment utilizes special highly selective circuits and makes it possible to work in channels between stations now on the air without "spillover" into the adjacent channels. The transmitter-receiver is completely housed in a single metal-shielded unit slightly larger than a shoe box.



Stepping Relays

By J. Packard Laird
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Buehler and Company
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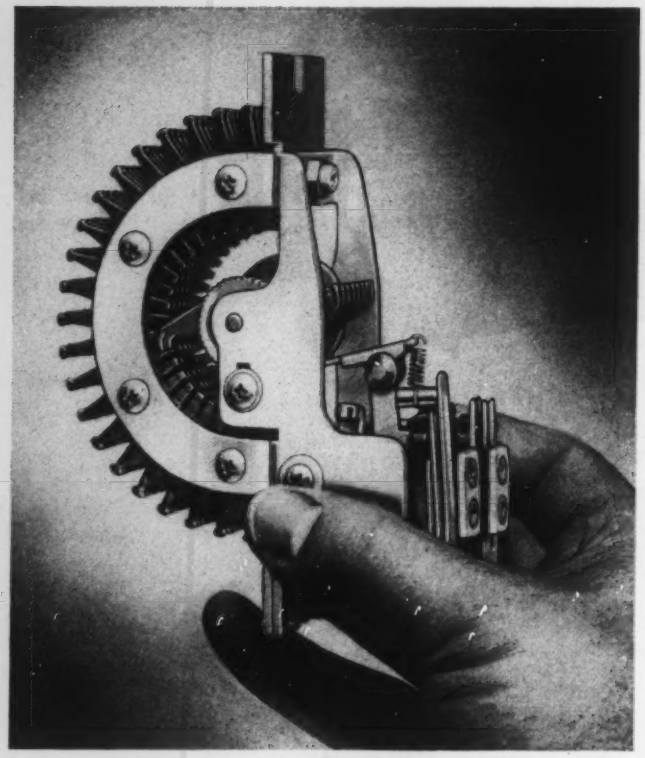
PROPER control of pneumatically or hydraulically powered automatic machines is one of the factors which determine the feasibility of such mechanisms as well as the limits of complexity. Without a simple, reliable and flexible control system the outstanding attributes of automatic-cycle machines are seldom realized. This article will therefore explore the principles and applications of a system which appears to offer greater advantages than most systems ordinarily employed.

There are two broad classifications of automatic machines which form the extremes to be found in industry. First is the rigidly coupled machine powered and co-ordinated by shafts, gears, cams and the like, and second is the externally controlled machine. This second type machine, with which this article will



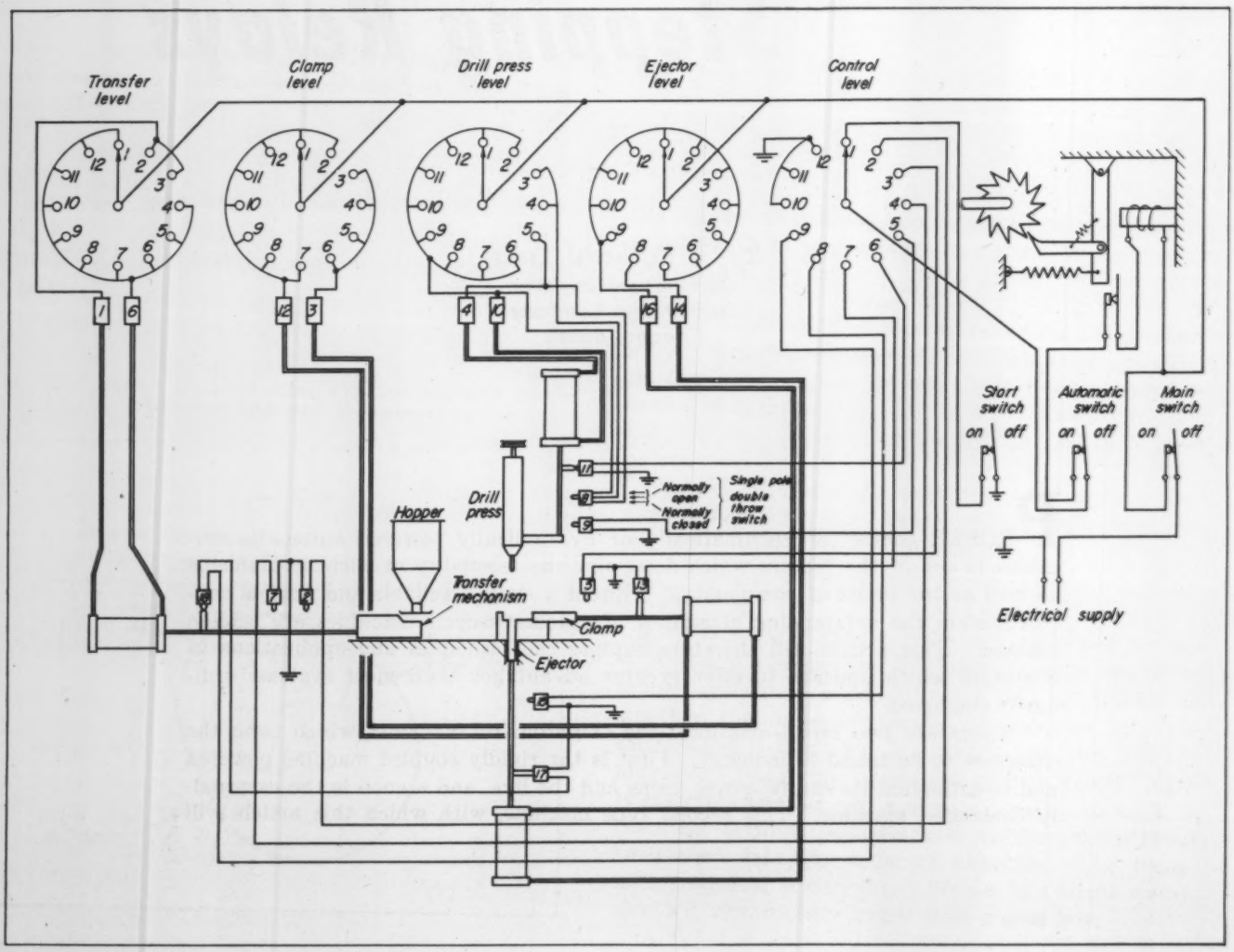
Photo, courtesy C. P. Clare & Co.

be specifically concerned, derives a great deal of its virtue by using power where power is needed and employing the control system only to regulate the application of power. There should not be any interconnection between the control and power elements except as master and slave, respectively. This is the weak point in rigidly coupled machinery. Keeping the control separate from the power is, in the opinion of the author, of vital importance since it assures a maximum degree of flexibility and usefulness, coupled with low cost.

In automatic-cycle or "sequential operation" machines the power comes from hydraulic or pneumatic cylinders and rotary motors which are controlled and regulated by solenoid or pilot-operated valves. The valves in turn are controlled by a main control element—in this instance a stepping relay. This relay, *Fig.* 1, is responsive to signals which cause it to pass on to the next step in the cycle. These so-called "proceed" signals come from proceed switches or

Fig. 1—Left—Typical stepping type relay utilized as the master control element for complex automatic machines

Fig. 2 — Below — Schematic control circuit layout for the automatic drilling process. Basic relay elements are at top



valves associated with the various movements of the machine. The main control element always sends a forward or reverse signal for the control of each cylinder at every step in the repetitive cycle so that every cylinder is always either in its correct position or in the process of getting there. The main control element therefore sends out signals to the different cylinders via the valves and receives an answer back when the job which was to be done has been completed.

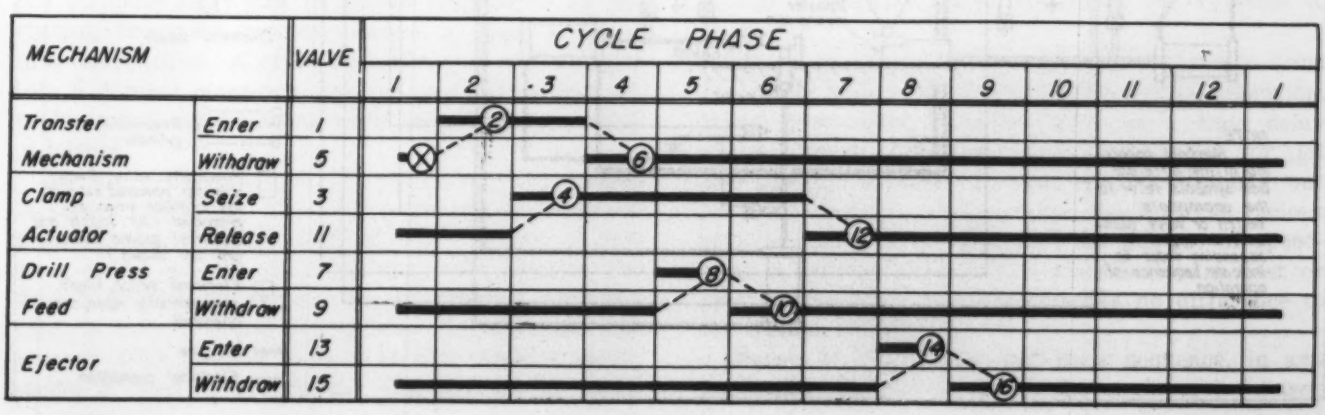
Obviously, simple systems can be mechanized for automatic operation without the need for a master control element such as described, but the point at which such a machine becomes so complex that completion of one step cannot initiate the next succeeding step directly must be determined by analysis. To facilitate illustration of stepping relay control of complex machine functions, a simplified system, schematically illustrated in *Fig.* 2, will be used. A piece which is to be drilled automatically is loaded by a transfer mechanism from a hopper into a clamping fixture. The clamp actuator seizes the piece, the piece is drilled, the clamp actuator releases its grip, and the piece is passed along by an ejector. The problem then is to devise some means of making these successive operations take place in an orderly fashion with maximum safety and speed. Although there are other ways of handling this problem, ranging from the use of self holding relays to the use of rotary feed, the present arrangement will illustrate the type of control system under discussion.

The controls which regulate the movements for this automatic operation are also shown in *Fig.* 2. The stepping relay consists of a stack of multiple-position switches keyed together and driven by a magnetically cocked spring-driven ratchet, shown schematically at the top of *Fig.* 2. One wiper and its associated contacts is referred to as a level. Each cylinder is controlled by one level which energizes the appropriate solenoid-operated valve, and one additional level is used for control. The position of the wipers in the different levels corresponds to the various steps in the cycle. It can be seen, therefore, that each cylinder is positively actuated to be extended or withdrawn at all points of the cycle. The extra level in the relay, known as the proceed level, is used for control purposes. The stepping relay will index one step when it gets a signal which says, "I have finished my job, you may continue with whatever comes next." The stepping relay must be able to receive such a signal from the appropriate element of the machine and from no other source, otherwise the relay might step from a false signal. The proceed signal enters the proceed level by way of the outside contacts and passes to the wiper and thence to the stepping magnet. This means that the relay will step only when the job which is under way has been completed since no other proceed signal can get through the proceed level. Once the relay has stepped, it is isolated from the proceed signal which caused it to index.

MAIN CONTROL ELEMENT for a complex machine having twelve cyclic steps and two transfer motions consists of one telephone type relay costing less than $30.00. Eight pneumatic cylinders, having strokes ranging from 3/16 to 10 inches, cycle through the twelve processing steps in less than nine seconds. Because of the complexity of the circuits for such a machine the author has chosen to employ a simplified approach which can be expanded to suit almost any set of conditions encountered

The signals which go to the stepping relay and cause it to move to the next position emanate from proceed switches which are actuated by the completion of the stroke of one or more cylinders. It is evident that, while the present illustration shows only one cylinder operating at a time, there may be several cylinders which operate simultaneously. In

Fig. 3—Sequence chart layout for the circuit shown in Fig. 2 used in tracing out the action of the control system. Number in circle indicates switch which initiates signal, dotted line shows progress of stroke and solid line indicates operation of the valves during the cycle



such a case the switches which initiate the proceed signal would be wired in series so that the relay would step only when all the movements had been completed. In the event of jamming or failure of any part of the mechanism, the worst that will happen is that the machine will stop, since failure to receive any proceed signal will preclude further operation.

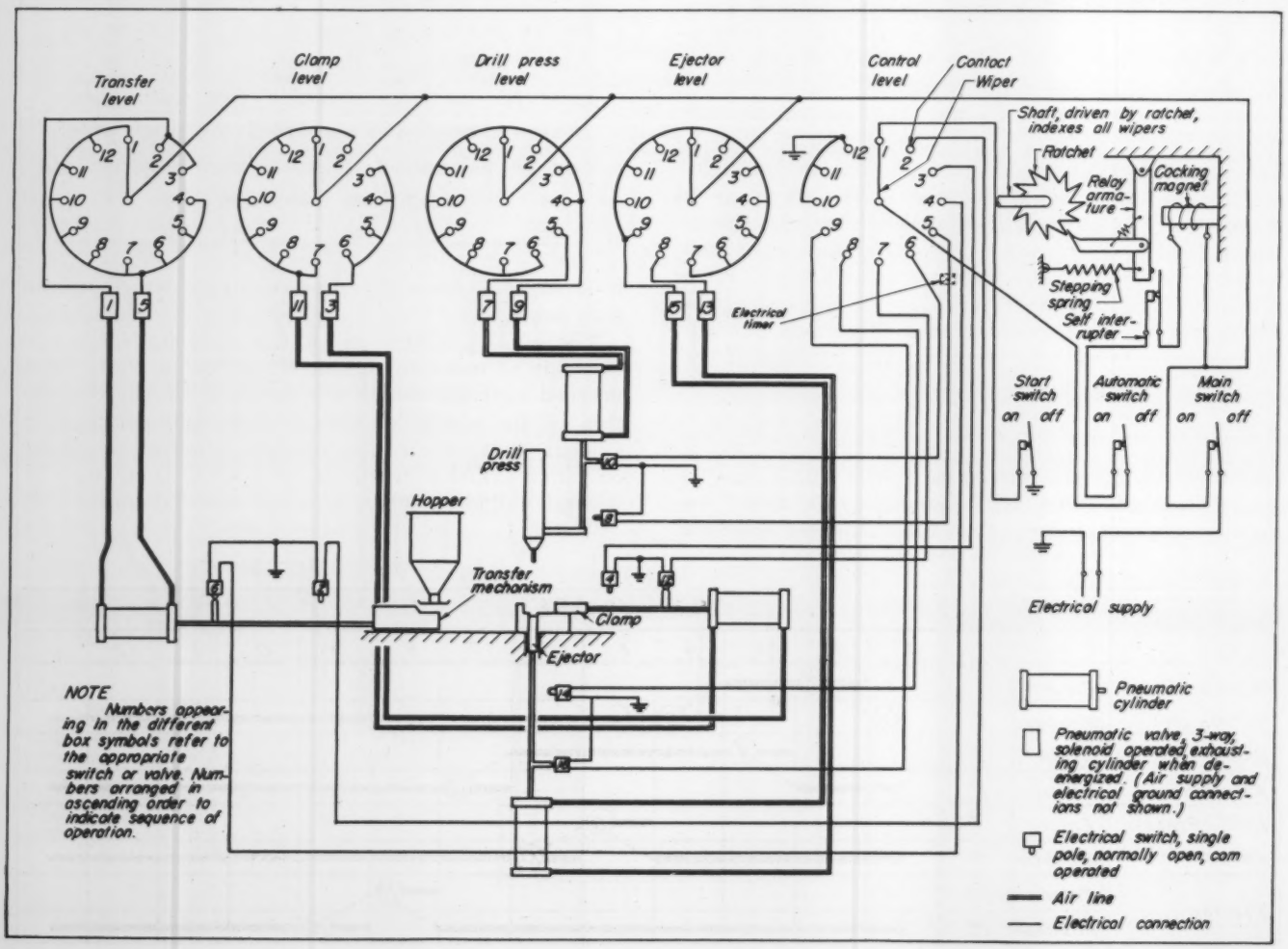
The start switch may be used in two ways. When it is closed, the cycle starts. If the switch is left closed, the machine will continue to operate automatically, cycle after cycle, while if a momentary contact only is made, or if the circuit is broken before the end of the cycle, the machine will complete that cycle but will not repeat.

The "automatic" switch in the "on" position causes the machine to proceed from one step to the next without manual attention. If this switch is thrown off, the machine will stop at the end of the job at hand. Momentary contacting of the switch will permit the next step to start but the machine will stop at the end of that step. The machine can therefore be operated either in steps or automatically.

The main electrical switch may be used for emergency shut off and for inching of the various movements. When the main switch is turned off, all the cylinder-control valves open so that all movement stops and the machine is "relaxed". This is important in the event of jamming and as a safety feature should personnel become entangled in the machinery. Even though parts of the machine may have to be moved by hand to remove some obstruction, when the main switch is thrown on, the machine picks up where it left off, all cylinders moving to their proper positions. In larger and more complex operations it is desirable to be able to turn off or isolate certain parts of the machine so that recovery after maintenance or jamups can be done one element at a time. This can be accomplished conveniently by the use of manual switches in the leads running to the solenoid-operated valves.

The sequence chart, *Fig.* 3, shows the order in which movements occur, the valves which are made to operate and cause this movement and the proceed switch operation which causes the stepping relay to index to the next cycle phase. If the sequence chart is traced through it will be seen that one movement takes place at a time, its completion actuating a pro-

Fig. 4—Modification of the circuit shown in Fig. 2 to allow for overlap in cycles and shorten the overall time cycle without impairing safety of operation



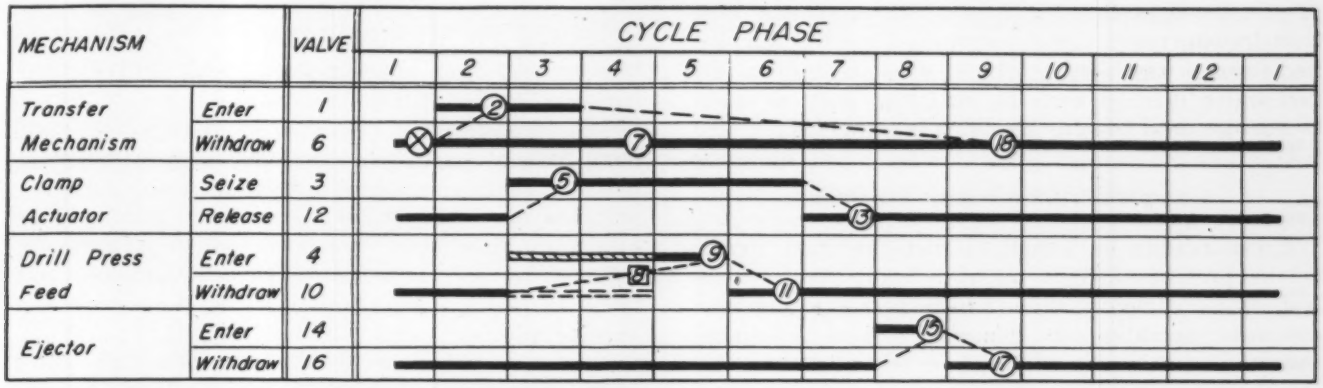


Fig. 5—Sequence chart layout for the modified system in Fig. 4. Shaded line indicates valve operation dictated by relay, dotted extension line shows action if safety switch is thrown and number in square is safety switch which is actuated by the stroke

ceed signal for the start of the next movement. The cycle phases take place in succession but duration is not restricted in any way by the controls shown. This means that the drill feed can be made fast or slow by adjustment of external speed-control valves associated directly with the pneumatic cylinder. Also while the stepping relay may include more positions than there are cycle phases, the unused positions are passed over automatically by autoindexing of the relay. The sequence chart is vitally important in evolving and tracing the action of the control system. It should therefore be the starting point for a thorough analysis of the cycle.

Control Unit Has Long Life

From an economic standpoint, the control illustrated in *Fig.* 1 is unusually low in initial cost. The proceed switches associated with the cylinders are of nominal price dependent on the type and degree of permanence desired, while the stepping relay costs no more than a pneumatic cylinder having a 2-inch bore. Maintenance of the stepping relay consists of replacing the ratchet and pawl every few million cycles to preclude breakdown. Maintenance on the other electrical and hydraulic or pneumatic equipment is conventional. Breakdowns from failure of the stepping relay can be almost discounted by designing the main control element so that it plugs into the machine. A spare unit, wired up and plugged into a dummy mounting, can be used for on-the-spot replacement, repairs being made on the damaged unit at leisure.

An interesting sidelight on flexibility of the system is shown in *Fig.* 4. The drill press can be actuated prior to the complete loading and clamping of the piece to be drilled. Consequently, this permits the drill to approach the work but not touch it until the piece is fully clamped in position. The machine can proceed after loading as soon as the transfer mechanism is clear of the clamp. Changes can be made to provide these two instances of overlap, and the time per cycle can be reduced by almost one second. Comparison of *Figs.* 2 and 4 will clarify the difference between the original machine and the modification. The sequence chart for the modified system is shown in *Fig.* 5. The overlap associated with the transfer mechanism does not involve any need for safety during movement while the overlap associated with the drill press feed must include a switch to make sure that the drill does not touch the work before the work is clamped. This last safety switch should never be called on to operate, but if a defective piece were to enter the machine and not load properly, this little switch might prevent drill breakage or worse.

In cases where an automatic process involves time delays as would be necessary in molding work, timers can be used to delay the proceed signal which would otherwise make the machine continue with the cycle. On control circuit 5 of *Fig.* 2 is indicated the insertion of an electrical timer. The proceed signal therefore enters the timer, thus starting the timing cycle. At the completion of the time delay, the timer sends the proceed signal on to the stepping relay. The system is therefore in no way disturbed by the introduction of a time delay. Furthermore, in cases when it is not practical to mount an electrical proceed switch on the machine for the purpose of determining when a movement has been completed, a timer can be used. In this case the timer is started by the signal which energizes the valve, and the timer sends a proceed signal on to the stepping relay after allowing a sufficient delay to permit the cylinder to move.

Use of timers in such applications is different from the use of timers for controlling the whole operation. When time delay is called for, use a time delay device; which action and speed are called for, let the machine proceed as fast as it may finish one job and can pass on to the next. Speed of the various strokes can be then controlled by the use of speed-control valves, whether the movements are fast or slow in reaching completion makes no difference to the control system.

Choice of movements and their sequence, in any particular instance, is up to the engineer in charge

of the development, but making the selection and then transforming it into a working reality is simplified through the basic principles of sequential operation which demand that the next step start as soon as but not until the previous step is completed.

Complete Automaticity Possible

It can readily be visualized that the start signal in the present example might actually be received from some other machine which performs another automatic operation. In this way, several automatic operations, each functioning sequentially, can be combined to provide a complex automatic machine capable of completely automatic assembly, inspection and packaging of some article. The combinations which may be possible are unlimited and no further illustration is given here for this reason. The use of overlap, both in the individual movement of the subunits and in the operation of complete sequential cycles within the overall machine, will speed up the cyclic rate without detracting from the foolproof and flexible operation which results with this type of sequential operation.

In order that authorized personnel shall be able to operate the machine conveniently during maintenance and that uninformed persons with manual curiosity cannot damage the machine, the following precautions should be observed in cases where auxiliary manual control of the individual cylinders is desired. First, regardless of what form the auxiliary switches may take, if they permit the human operator to initiate some movement which is normally initiated by the main control element, provide complete operating instructions covering their use, and provide in these instructions for bringing the machine to some "starting point" before returning it to "automatic" operation. This will simplify getting the machine back into service and preclude mishaps. Seccondly, make sure that the extra controls so provided are protected by a cover plate, lock, or other device which will prevent tampering by unauthorized personnel. One means of accomplishing this is to provide switches which plug in. This will mean that maintenance personnel will be able to perform their duties but others cannot interfere with the correct operation of the machine since the switches are not permanently installed.

Controls Tension On Dancer Roll

SPECIFICALLY designed as a constant tension control for loops of material in process, such as paper webs, the Short-Stroke Dancer Roll Unit (VSS) comprises a two-coil, air core, iron plunger reactor connected into a special phase-shift bridge circuit. It controls the excitation of a motor or generator field. Output of the bridge regulates the grids of two Thyratron tubes in a conventional rectifier circuit. A core movement of 9/16-inch results in the maximum output of 230 volts, 2.0 amperes, while a minimum voltage of 30 volts may be obtained. Thus a wide range of field control is available, with nearly linear relationship between output voltage and VSS unit plunger displacement. An anti-hunting circuit can be provided as a standard addition with this unit to insure stable control in applications where stability of operation is a problem. A field loss relay is also available as protection against field failure.

When used as a constant tension control unit, the reactor of the VSS is mechanically linked to a dancer roll supported by the web of the material being processed between two sections of the machine. Any change in the speed relationship of the section drives will move the dancer roll, causing the reactor plunger arm to move. This changes the VSS output so as to slow down or speed up one of the sections or rolls, restoring proper speed and tension relationship. The accompanying photograph and schematic drawing show a typical application of the tension control unit, a machine for coating paper with plastic. A paper unwind reel is driven by a 3-hp direct-current motor whose speed is changed by varying the output of a 3-kw direct-current generator. The VSS controls the output of this generator by varying its field.

In this particular application, the generator has an auxiliary field which is of constant strength and in opposition to the VSS field. With this arrangement the resultant field strength of the generator can vary

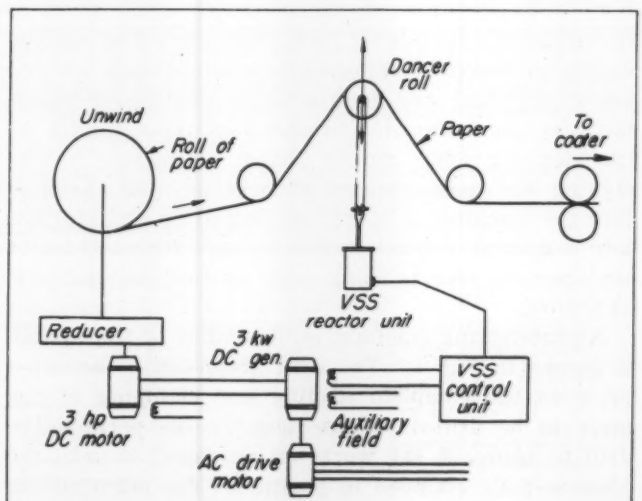
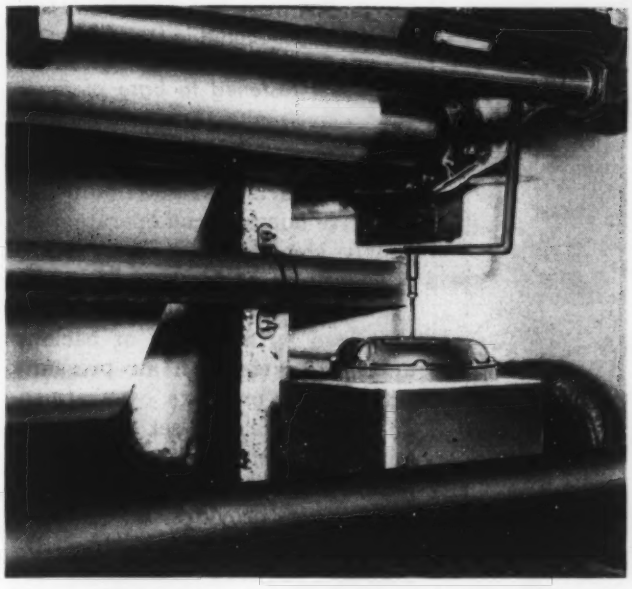


Diagram of Tension Control Unit



from maximum in one direction through zero to a maximum in the other direction. Thus, the polarity of the generator can be changed, causing the unwind motor to act either as a motor or drag generator. The unit thereby controls the unwind motor speed to maintain the proper tension throughout the entire full-to-empty paper-roll unwind cycle.

Another application as a speed setting device is where the VSS controls a motor speed in proportion to the position of some object or mechanism. An example is the automatic control of lathe cutting speeds, where the plunger of the reactor unit is linked to the lathe cross feed. Here it is a simple matter to include a mechanical linkage that will regulate the lathe motor speed to give a constant cutting speed. Manufactured by the Reliance Electric & Engineering Co., Cleveland, the unit is adaptable to a wide variety of applications because of the low effort characteristic of the plunger and the infinite control available.

Dust-Free Drive in Vacuflow Machine

By Paul E. Fischer
Chief Engineer
Mechanical Division
General Mills, Inc.
Minneapolis 13

THE "Vacuflow" machine, produced by General Mills, Inc., operates on principles whereby powdered or granulated materials are packed into containers and tamped down by the application of vacuum and the alternating atmospheric air pressure which is consequent upon its release. Obtaining proper tamping of the product to a predetermined density may require several cycles. If the average filling time for each container is to be reduced to a minimum, it is desirable to have an arrangement whereby several containers are processed at one time in continuous engagement with the filling heads. By this arrangement, while one container is entering the filling machine, another completely filled container is leaving, while several others, in various stages of the filling op-

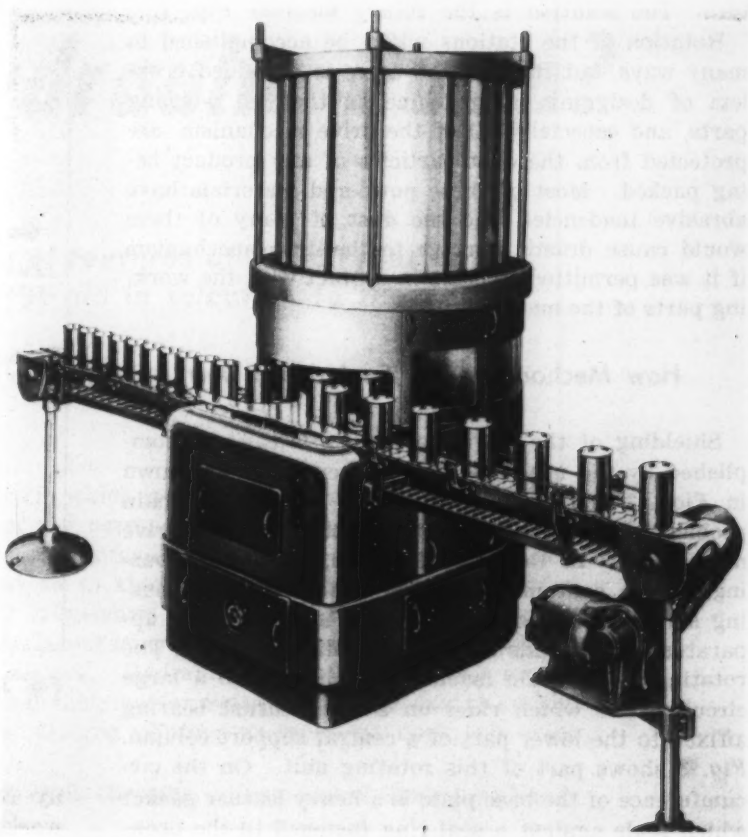


Fig. 1—Vacuflow machine fills containers with powdered or granulated materials and tamps down contents by applying vacuum and atmospheric pressure alternately

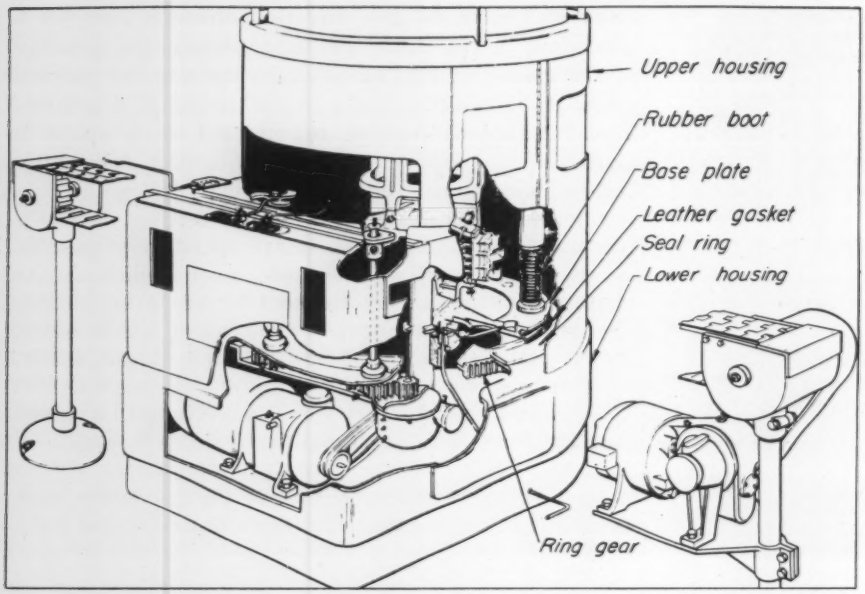


Fig. 2—Cutaway view shows how drive mechanism, mounted in lower housing, is sealed from upper area by leather gasket fastened to base plate

eration, are still within the machine.

Such a design requires a separate filling head and lifting table for each of the containers to be processed at one time, and each filling station with its lifting mechanism must operate independently. These stations must also be movable so that each may be brought into the receiving and discharge position in turn. The solution is the rotary machine *Fig.* 1.

Rotation of the stations might be accomplished in many ways, but in this case there is an added problem of designing the machine so that all working parts, and especially all of the drive mechanism, are protected from the dust particles of any product being packed. Most of these powdered materials have abrasive tendencies, and the dust of many of them would cause drastic damage to the drive mechanism if it was permitted to come in contact with the working parts of the machine.

How Mechanisms Are Sealed from Dust

Shielding of the elevating pistons is easily accomplished by the use of flexible rubber boots, as shown in *Figs.* 2 and 3. The means of solving the main problem required a separate housing for the drive mechanism. In this machine then, the lower housing, *Fig.* 2, contains the drive, while the upper housing acts as a support for the feed and discharge apparatus and shrouds the rotating filling stations. The rotating part of the machine is built up on a large circular base which rides on a large thrust bearing affixed to the lower part of a central support column. *Fig.* 3 shows part of this rotating unit. On the circumference of the base plate is a heavy leather gasket which seals against a seal ring fastened to the opening in the upper surface of the lower housing. This provides that the large dished ring gear attached to the bottom of the base plate of the rotating units, and all other parts and power units in the drive housing, can operate completely shielded from the product or any of the dust particles.

The drive mechanism is doubly protected by a system of backing up the gaskets with air pressure. To do this, pressure over atmospheric pressure is set up by exhausting the pneumatic lifting plate cylinders into the drive housing. This provides a continual bleeding of air out of the drive housing, thereby excluding the entry of any dust-laden air from any outside source.

Advantages of a shielded drive such as this, even where the material being processed has no appreciable abrasive tendencies, will be readily recognized by maintenance mechanics who have worked on unshielded machines used for packing powdered products. Where abrasiveness is present, this protection is imperative to give the machine a longer working life.

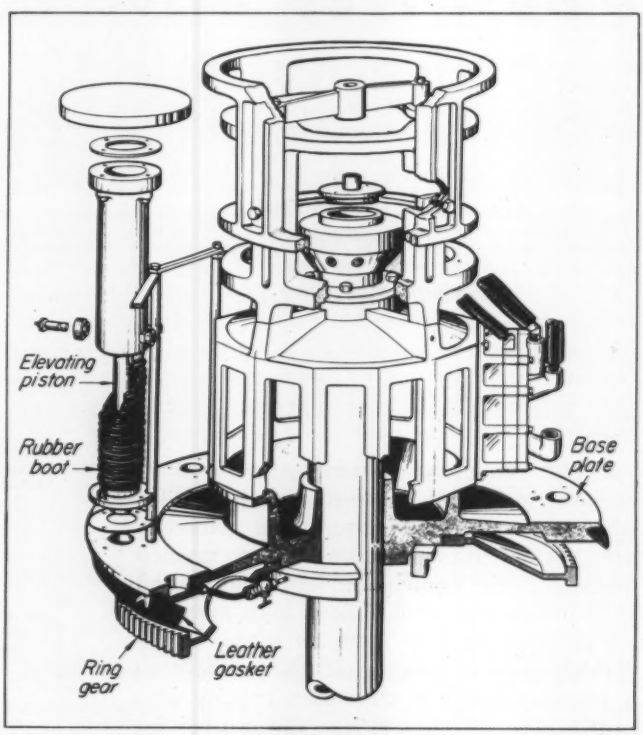
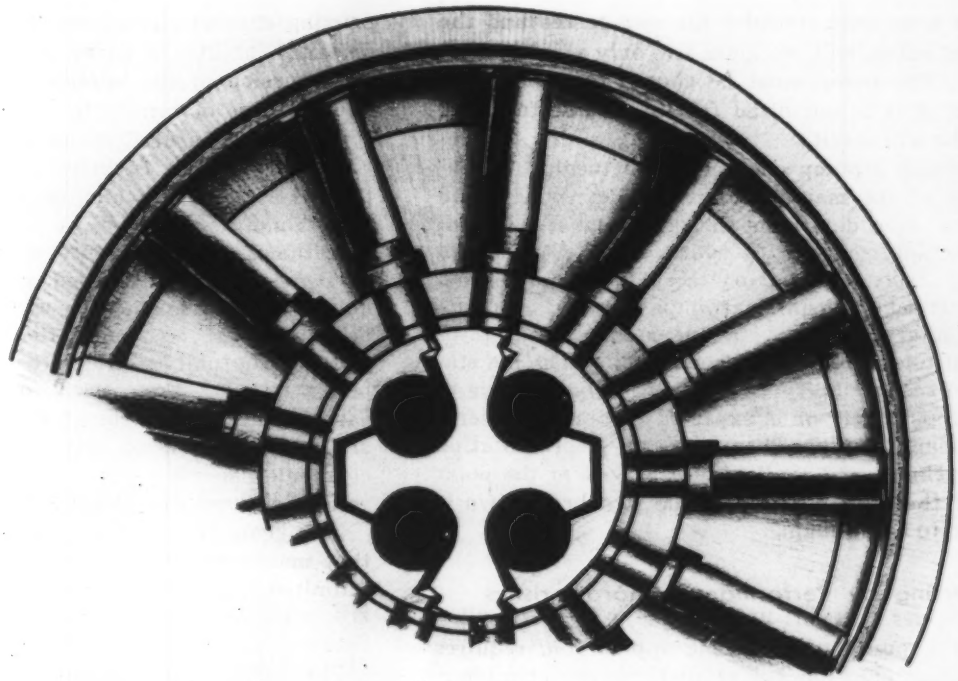


Fig. 3—How elevating pistons of machine are shielded by flexible rubber boots



By Ransom Tyler
The Oilgear Co.
Milwaukee

Which Hydraulic Pump?

Comparison of features of basic types of hydraulic pumps aid in selection to fit the job

PROSPECTIVE users of a pump which is to become an element of a machine are somewhat in the position of the patron of a restaurant which has a long menu with much of it written in an unfamiliar tongue. Many commercial machine elements are standardized as to shape, performance, strength or other characteristics, the major factor influencing the choice of the precise one to be used being the reputation of the manufacturer. This is not true in the field of pumps for power transmission service. Hydraulic pump characteristics are as diverse as flesh, fish or fowl and their performance may be as varied as pie, pudding or parfait; with some designs offering as much as apple pie with cheese—*a la mode.*

Vast differences exist, however, in choosing a pump and in choosing a meal;

the diner need only consider his own tastes and the meal, once eaten, will, we hope, live only as a pleasant memory. The pump must be chosen to perform its task, and, if it is not fitted for its specific function, a headache will result.

In choosing a pump one should not neglect a consideration of the manufacturer. His experience and reputation often determine the performance levels of the important components which mean so much in producing truly satisfactory service—such as adequate shaft seals; clean, sharp pipe threads; adequate lubrication at all points; or the maintenance of dimensional tolerances in the mountings. Also, his stability and responsibility mean much if the pump is to be used repetitively or is expected to remain in service for many years. Then, too, his representation must be reliable and available for service at the point of use of the unit if time loss due to a breakdown is to be held to a minimum.

Selecting by Performance Characteristics

Fitting a pump to a specific application, requires consideration of a number of performance characteristics, *Fig.* 1. Power transmission pumps are built by many manufacturers and are designed in a considerable number of fundamentally different forms. While there is a great deal of variation in the characteristics of various designs within one type, in general the majority of any type have common characteristics. A knowledge of these characteristics is essential to the proper selection or application of a unit.

Chief characteristics to consider in choosing a pump are: Capacity, pressure, input, speed, slip (internal leakage), type of fluid required, efficiency, control requirements, durability, reliability, quietness, pulsation amplitude and frequency, physical size, weight, ability to operate in various positions, self-priming characteristics, speed of response to varying demands, ability to carry peak overloads, and cost. A discussion of the implications of these characteristics will be of benefit in understanding the various types of pumps used in power transmission service.

CAPACITY: The capacity or delivery of a pump is the amount of fluid which the pump will deliver under rated conditions of pressure and speed or, under some conditions, at the pressure and speed at which it is to be used. The required capacity is often determined by equipment with which the pump is to be used but more frequently the capacity and pressure can be mutually varied to provide the required power output. For positive-displacement pumps the capacity is the product of the displacement per revolution and the speed, less the slip. The actual delivery under specified conditions, divided by the theoretical delivery is the volumetric efficiency.

The geometry of some designs of pumps is such that maximum performance is obtained only through a limited range of capacity. While units may be available outside this range they should be applied with caution.

PRESSURE: The maximum pressure to be used in a system is fixed if the equipment is in existence. If the equipment is in the design stage, however, it is frequently possible to adjust the maximum pressure through a considerable range. With the development of better piping, controls, and accessories there has resulted a natural tendency to design for higher and higher pressures. Higher pressures generally result in physically smaller and less costly equipment. However, high pressures must be used with caution and understanding of the problems of leakage, shock, dynamic forces, and the elastic effects of a fluid which, contrary to the beliefs of many, is not incompressible.

Leakage is generally through close fits and is therefore related to viscous flow. Thus, if the clearances

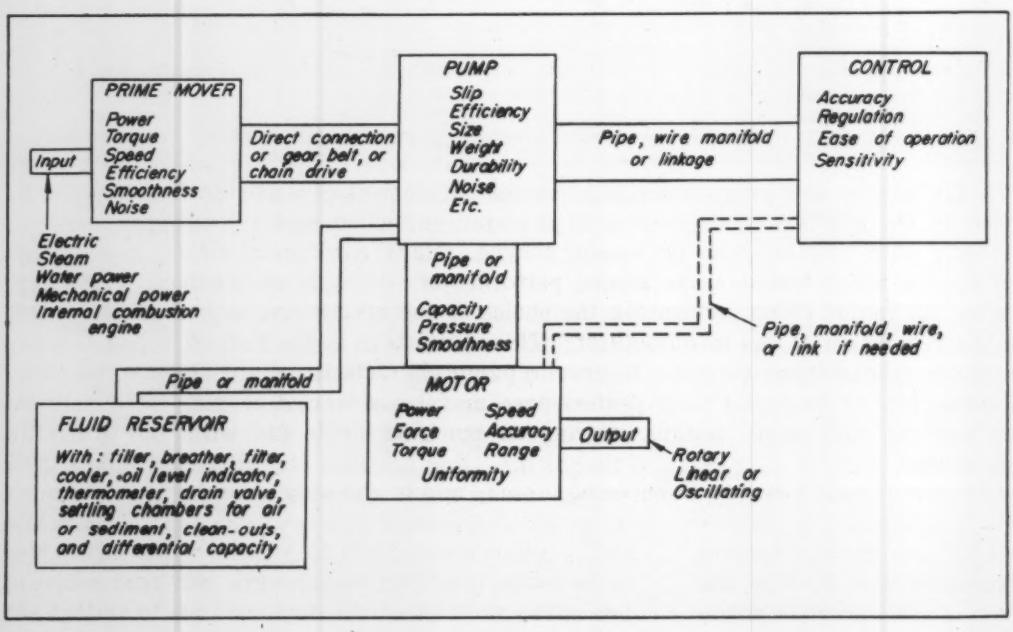


Fig. 1 — Schematic of elements in a hydraulic system lists important performance characteristics of components

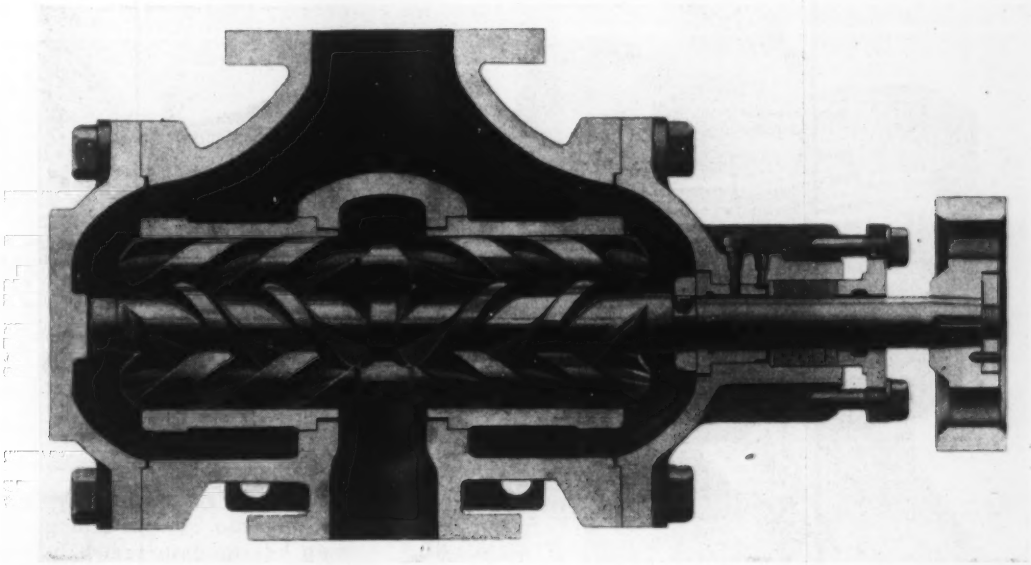
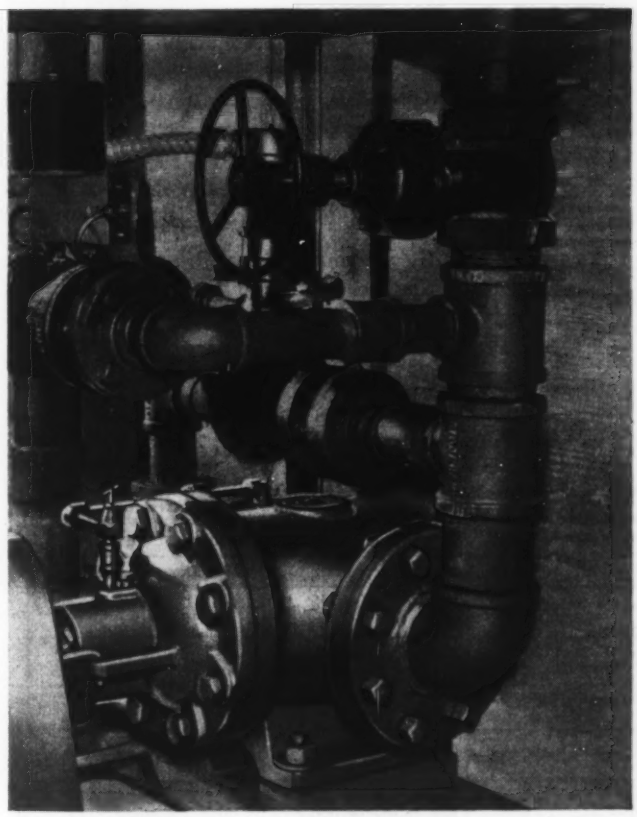


Fig. 2—Right—De Laval Imo pump for pressures up to 500 psi. Unit has three moving parts with full axial flow delivery. Two idler shafts mesh with screw type driven shaft

Fig. 3—Below—Installation view of pump for powering hydraulic elevator. Pump is type shown in Fig. 2



remain constant, the leakage or slip of a pump is substantially proportional to pressure. Some fits change under the stresses induced by increasing pressure and thus, since the clearances generally increase, the slip will, in these cases, increase at a higher than linear rate. Thus pumps and other equipment designed for the higher pressure ranges must be closely fitted and well designed for maximum rigidity.

Sudden changes in the energy level of fluids due to change in pressure often give rise to shocks. This is severe and destructive if, for instance, pressure is released in a large quantity of fluid at an uncontrolled rate. The many small shocks produced by individual pistons in multipiston pumps may cause undesirable noise and premature breakdown. The effects of shock, of course, increase with the increase of pressure.

High pressures often result in very high velocities through orifices or orifice-like openings in the hydraulic equipment. These high velocities may exert dynamic forces which unbalance elements which are in perfect static balance. This is often demonstrated by severe "kicks" encountered when shifting sliding type, balanced, valves. Also, these high velocities sometimes result in erosion.

Elasticity Affects Short Cycles

Other effects of elasticity, aside from shock, are time lags and "springiness". Since the system energy is increased by the potential energy stored in elasticity a definite period of time must be taken to permit a given power input to supply it. If the overall time cycle is short, this period may be an appreciable portion of the cycle. Also, if a given system is operated over a wide range of speeds the power input at slower speeds may be so small that the energy storage may require a considerable period.

Fluids are much more elastic than the usual structural materials. Thus a power transmission system, using a long column of oil, may be likened to a drive through a springy shaft. This sometimes results in undesirable periodic fluctuations or other variations if the stress (pressure) is too high.

Equipment designs and methods of construction and application have, of course, been developed which avoid the undesirable effects of higher pressures within accepted commercial ranges. When planning an application to operate outside normal commercial ranges, the foregoing points should be questioned.

INPUT SPEED: This, of course, must be related to the prime mover to be employed. Frequently the

Fig. 4 — Rotary gear pump manufactured by the Roper Corp. This pump employs venturi suction and discharge ports shown in Fig. 5

most convenient and dependable method is direct connection to an electric motor. However, some applications are made where the power is taken from some shaft, or from a variable-speed source. The pump to be used must, of course, be capable of operating efficiently at this speed, and with maximum utilization of its capabilities.

SLIP: This has been mentioned under the heading of pressure. High slip is generally undesirable due to the change in output characteristics with change in load. Ideal operation would be achieved if no slip were to be permitted. However, this is impossible due partly to the necessity of supplying lubrication to the running fits. The total apparent slip consists not only of leakage, but also to the change of delivery due to the elasticity of the fluid, and to the mechanical deflection in the pump parts. Sometimes this latter factor is used in a negative sense, and then compensates for the other apparent slip factors by actually increasing the pump displacement with increasing pressure.

TYPE OF FLUID: Almost all high-speed positive-displacement pumps are designed to operate only on good lubricating oil. Some lower-speed pumps and

Characteristics of Power Transmission Pumps
(Comparing features of five basic types)

Characteristic	Reciprocating	Gear and Lobe	Vane	Rotary piston	Centrifugal
Capacity range	Very low to high	Very low to high	Very low to medium	Low to high	Medium to high
Pressure range	Low to very high	Low to medium	Low to medium high	Medium to high	Very low or very high
Input speed	Low	Low to medium (screw types can be very high)	Medium to high	Medium to high	High to very high
Slip	Low (when kept in good condition)	Medium to high	Low to medium	Low to medium	
Type of fluid	Can be fitted for any	Can be fitted for most	Lubricating oil	Lubricating oil	Any low-viscosity fluid
Efficiency	Medium	Low to medium	Medium to high	High	High (when operated at rating)
Control requirements	Generally not controllable	Not controllable	Some types available with volume or pressure controls	Many types of standard or special controls	Characteristics controlled by speed only
Durability and reliability	Generally good	Fair to good	Fair to good	Generally good	Good
Noise	Fairly loud to loud pounding	Fairly quiet to fairly loud grinding or howling noise	Fairly quiet to fairly loud whine	Fairly quiet to fairly loud growl or whine	Fairly quiet high pitched whine
Pulsations	Large, low frequency	Medium high frequency	Small, high frequency	Small, medium frequency	None
Physical size and weight	Large	Small to medium	Small	Small to medium	Small
Ability to operate in various positions	Generally built for horizontal mountings	Can be fitted for any position	Can generally operate in any position	Can generally be fitted to operate in any position	Can be fitted for any position
Speed of response to varying conditions	Depends Upon Controls Provided				
Ability to carry peak overloads	Can generally carry high overloads	Depends upon construction and rating	Overload ability limited	Depends upon construction and rating	Characteristics prevent overloading

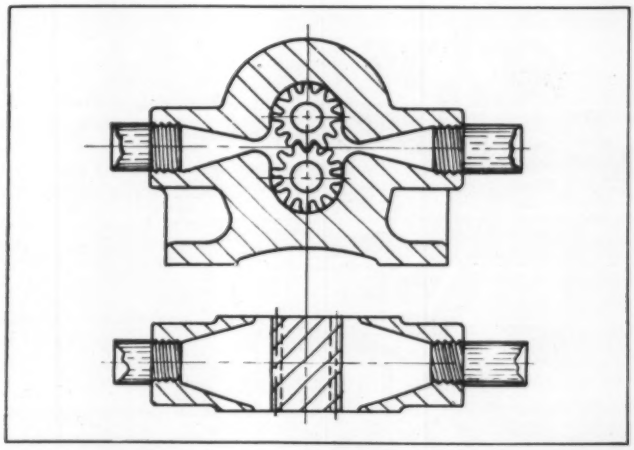


Fig. 5—Sectional view of pump shown in Fig. 4. Suction and discharge ports are elongated, tapered openings extending to and across the full center area of the gear bores. This provides a uniform distribution of liquid

centrifugal pumps can be used with water, soluble oil or other fluids where the size of the system or other considerations precludes the use of oil. In most instances the cost of the fluid used is a small percentage of the total. It is preferable to use a good lubricant, which will prolong the life and increase the efficiency of the system, than to economize on fluid and pay repair costs. An exception may sometimes be made when the danger of fire is great, although many operators have found it more desirable to provide additional safety equipment than to operate equipment which is less desirable from other standpoints merely to be able to use water as a fluid.

EFFICIENCY: The effect of efficiency is often overrated or underrated when considering the desirability of a pump. In the past a great majority of applications have been of small power capacity or of an intermittent nature. The actual cost of power has been low in comparison to the value of the product processed. Thus the effect of a change of a few per cent in efficiency has been neglected. In such a case the consideration of efficiency as such is superfluous. However, a unit of low efficiency must naturally produce a greater quantity of heat, which must be dissipated if excessive temperatures are to be avoided. A unit of low efficiency, even in small sizes, may require excessive oilpot capacity, or perhaps the addition of a heat exchanger as compared to a high-efficiency unit.

On the other hand there are a number of drives of greater power capacity operating continuously, in which the actual power cost may be considerable. The loss of one per cent in the efficiency of a 100 hp drive operating continuously will amount to $175 a year at an average power cost of 2 cents per kilowatt-hour. In addition the cost of the cooling water often required on a high-capaicty drive is of some importance.

CONTROL REQUIREMENTS: The type of work to be

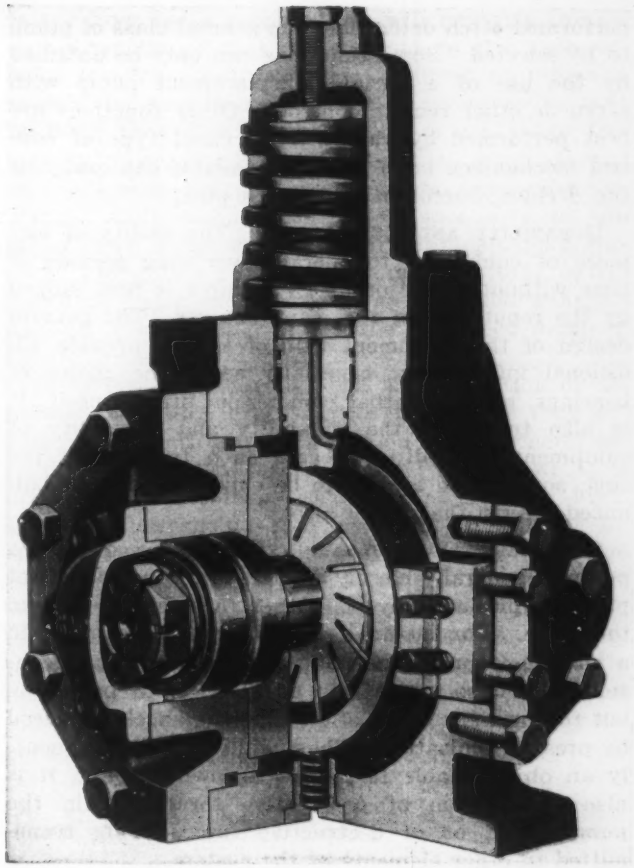
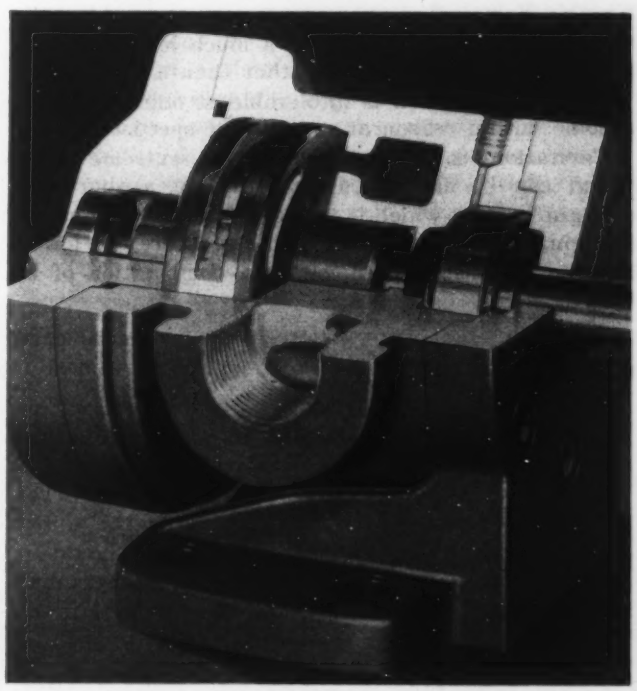


Fig. 6—Above—Variable-volume vane pump designed by Racine Tool and Machine Co. Delivery of pump is varied by changing the relative position of the pressure chamber ring to the rotor, increasing or decreasing the displacement

Fig. 7—Below—Vickers vane type pump has cartridge containing all pumping parts that move



performed often determines the general class of pump to be selected. Some functions can only be obtained by the use of a variable displacement pump with servo or other remote controls. Other functions are best performed by valves. The exact type of control mechanism, or of valving available can easily be the deciding factor in selecting a pump.

DURABILITY AND RELIABILITY: The ability of any piece of equipment to operate over long periods of time without minor or major failures is best judged by the reputation of the manufacturer. The general design of the equipment will, of course, provide additional information, especially as to the choice of bearings, seals, or other commercial fittings used. It is also true that the reliability and durability of equipment generally increases as a function of the cost, so that the service to be expected must be balanced against that factor also.

QUIETNESS AND PULSATIONS: Noise made by a pump is generally closely related to the pulsations of pressure produced by it. Other factors may add to the noise. For instance, misaligned timing gears in a lobe pump or a screeching packing may cause considerable noise which has no relation to pulsation, but the primary cause of noise is the shock produced by pressure pulsation. Thus, while noise is frequently an objectionable factor on its own account, it is also a symptom of destructive forces within the pump itself, or of destructive forces being transmitted to other elements of the system.

Effect of Speed on Noise Level

While noises of great amplitude are caused by severe shocks, the most objectionable noises are frequently caused by low-amplitude vibrations of some particular band of frequencies, or containing objectionable harmonics. Almost all pumps can be made to run more quietly and with a much less objectionable noise if run at a low rather than a high speed. Thus, a pump which is intolerable at one speed may become within reason at some lower speed.

Cavitation is another source of extreme noise which can be eliminated by providing a short and straight suction which is free of restriction, by supercharging the suction with a low pressure, by lowering the operating speed, or by a combination of all these.

PHYSICAL SIZE AND WEIGHT: It is desirable, of course, that these be kept to a minimum consistent with durability.

OPERATING POSITIONS: Ability to operate in various positions is important only on portable machinery, or when it is necessary to drive the pump from a vertical shaft. However, the requirements of the unit as to relative position with the oil level should be checked. Some pumps must run dry while others must be located at some point below the oil level in the supply tank.

Almost all positive displacement hydraulic pumps

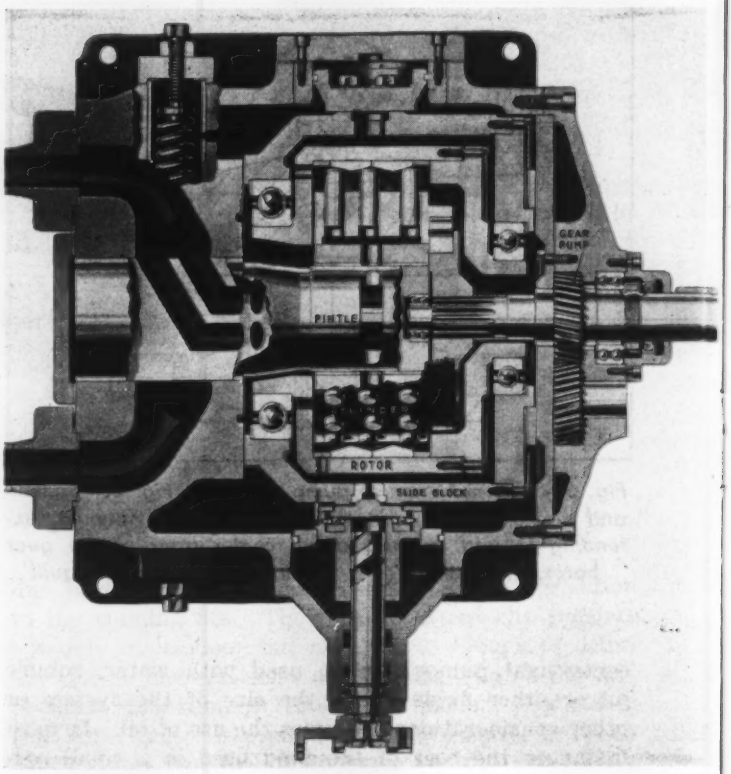


Fig. 8—Sectional view of an Oilgear rotary piston pump having variable displacement

are capable of operation without special attention to priming. However, they vary in their sensitivity to suction head, some being capable of operating under rather extreme conditions in this respect. Regardless of type of pump, however, the effort which can be expended in reducing the suction lift or in removing restrictions or bends in the suction line will be justified by the improvement in operation gained. Under pressures below atmospheric the dissolved gases in the fluid are thrown out of solution and the bubbles so formed, plus those due to mechanically entrained gas, are greatly enlarged. The result is a great increase in noise and shock, closely akin to cavitation.

Sensitivity of Control

SPEED OF RESPONSE: All hydraulic power transmission devices must have some means of control. In a great many installations the chief factor in selecting hydraulic operation is the ease with which pressure, torque, speed, volume, direction, or some other function or combination of functions can be controlled. The control means may be inherent in the pump, such as is frequently the case when variable-displacement pumps are used; or they may be external, as when the constant pressure and flow of a constant-displacement pump are modified by suitable valving. The speed of response of the control means has a considerable bearing on such items as safety (affected by the overrun after an emergency

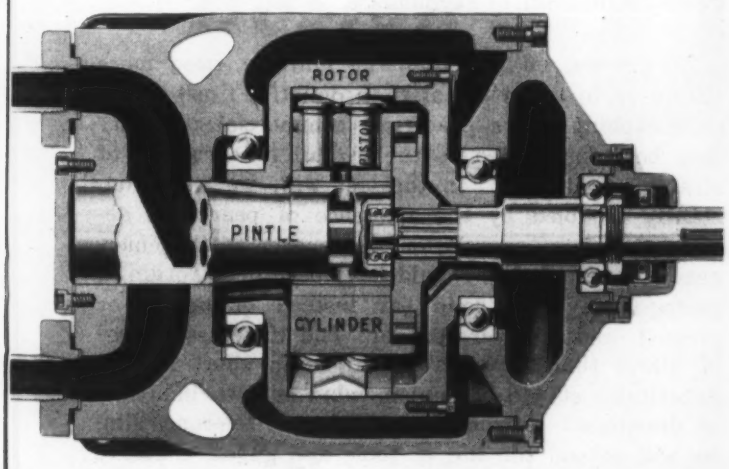
stop is operated) or process lag which controls the accuracy and sensitivity of an automatic control.

OVERLOADS: The maximum pressure which a positive displacement pump will generate is easily controlled by the use of some valve or other pressure controlling device. However, the establishing of the limiting pressure rating of a particular type of unit depends upon many factors. The standards set up by different manufacturers vary to the extent that some pumps will operate for short periods at much higher than rated pressures, while others are sensitive to such temporary overloads. This should be considered both from the standpoint of process demands, which sometimes are subject to unpredictable fluctuations temporarily above normal ratings, and also from that of rate-of-change of demand and the rate-of-response of the pressure-control device to such change. Rapid changes in demand often produce shocks resulting from the lag in control devices which are unsuspected in severity and result in "mysterious" failures.

COST: While the element of cost is certainly of significance in any design and must be considered when selecting components, it must be strictly subordinated to performance in the sense that any price is too high for a product that will not give the required results, or that will continue to give these results for the length of time required to return a profit. In considering costs it is necessary to bear in mind that direct comparisons of units are frequently misleading and that the final result desired is the lowest cost of the complete unit. For instance, while comparable performance may be obtained from a high-speed high-priced pump and a low-speed low-priced pump, the overall cost may be reduced by using the former if an expensive gear reduction is required to adapt the low-speed pump to the machine.

Some elements of cost, such as installation or assembly of piping, are easily overlooked as they appear in accounting to be a portion of the general assembly or erection costs. When broken down it is often found that these costs are surprisingly high. Consideration should thus be given to ease of installation and to skills and abilities of the personnel assigned to installation. The latter is important, since some types of pipe fabrication require equipment and methods unavailable in some plants. A complete packaged unit, purchased assembled by these methods, may be cheaper and better than a number of individual components which, individually may be cheaper.

Fig. 9—Sectional view of an Oilgear constant-displacement, rotary reciprocating piston pump



Designing System as a Unit

A hydraulic system is a unit and should be considered as such in a design. It is frequently a major component of the machine of which it forms a part, both in its relation to the work which the machine performs and in its proportion of the machine cost. It is therefore necessary to consider the design of the hydraulic system as a unit; to select hydraulic components which complement each other, and to connect and install them in such a way that their normal functions are not hampered.

Elements of a simple hydraulic system and some of the performance characteristics which are important in their design or selection are shown schematically in *Fig.* 1. These units are all essential in the simplest as well as the most complicated hydraulic power system. The best combination of character-

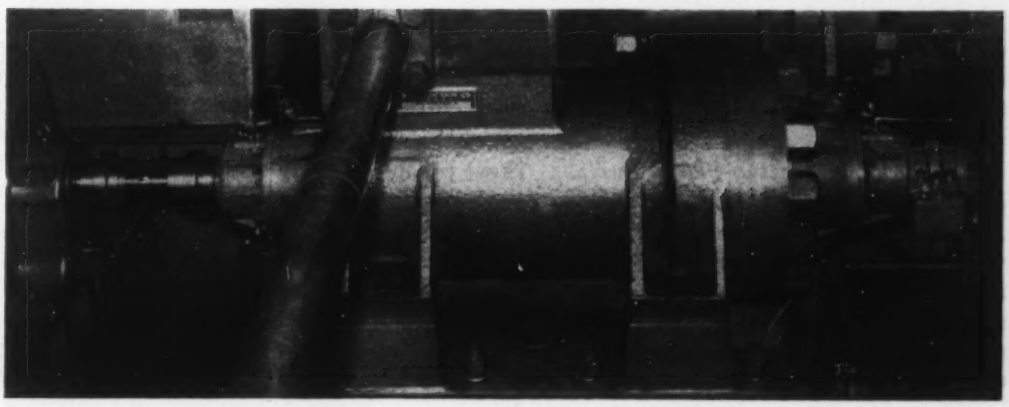


Fig. 10—Right — Byron Jackson pump of the double-case, double-volute centrifugal type. Three of these pumps operate an 18,000-ton forging press

istics of the final output is the designer's aim, and the assembly of all these components must be in balance to produce them.

TYPES OF PUMPS: In discussing the characteristics of specific types of pumps it must be realized that each manufacturer designs to enhance the virtues and to remedy the faults of his product to the greatest possible degree. Thus it will be possible that any characteristic which is common to many designs may be intensified greatly in one or entirely absent in another. However, a guide as to the usual characteristics is useful in restricting the field for intensive study, or as a reference for comparison in specific cases.

Five General Types

Since the general construction of the various types of fluid power pumps are well known or adequately described in other literature, only sufficient description will be given to identify them and to illustrate their characteristics. Power transmission pumps, in general use, can be classified into four types of positive-displacement units, and one velocity type (the centrifugal pump).

Crank and Plunger Reciprocating Pumps: These are the familiar single or multiple-piston pumps which were developed from hand-operated pumps and are thus the oldest form of power pumping equipment. They are available as single cylinder, duplex or triplex and single or dual-pressure types, as well as even one variable-displacement type. They are now used principally for service beyond the ranges of other pumps, or where their mechanical simplicity and familiarity to ordinary repairmen is of major importance.

Gear or Lobe Pumps: These rely on the meshing of two toothed or lobe-shaped rotating elements to carry the fluid through the housing and force it out the discharge port, *Figs.* 2, 3, 4 and 5. They are made in many variations, including external and internal gears, helical and herringbone tooth form, screw type, and in many types of special tooth or lobe forms.

Vane Pumps: In these pumps, *Figs.* 6 and 7, vanes of various forms are carried in a rotating member in such a manner that they may disappear within the rotor to confine a portion of fluid in a chamber of decreasing dimensions, thus forcing the fluid through the discharge port. These are also of many designs, some adapted for pumping gas, as in refrigerating systems.

Rotary Reciprocating-Piston Pumps: These pumps generally consist of rotating cylinders carrying a number of pistons disposed either axially or radially which are forced to reciprocate by eccentric rings or angular plates. The piston discharge is rectified by check valves or ported valves related to the rotation so that the inlet is connected to the piston during the suction half of the revolution and the discharge port is connected during the pressure half. These are commonly built as variable-displacement units, *Fig.* 8, although constant-displacement types, *Fig.* 9, are also available.

Centrifugal Pumps: These pumps are frequently used in power transmission systems although their characteristics are not subject to the type of control generally required. In *Fig.* 10 is shown an installation of three centrifugal type pumps for operating a large forging press. Industrial service usually demands operation over wide ranges of flow and pressure, including shutoff conditions. Centrifugal pumps are difficult to control at either fully by-passed or shutoff conditions.

In the accompanying table, the five types of pumps are rated with reference to the characteristics discussed in this article. This tabular form is presented for its usefulness as an easy reference when selecting a pump best suited for a specific hydraulic system.

They Say...

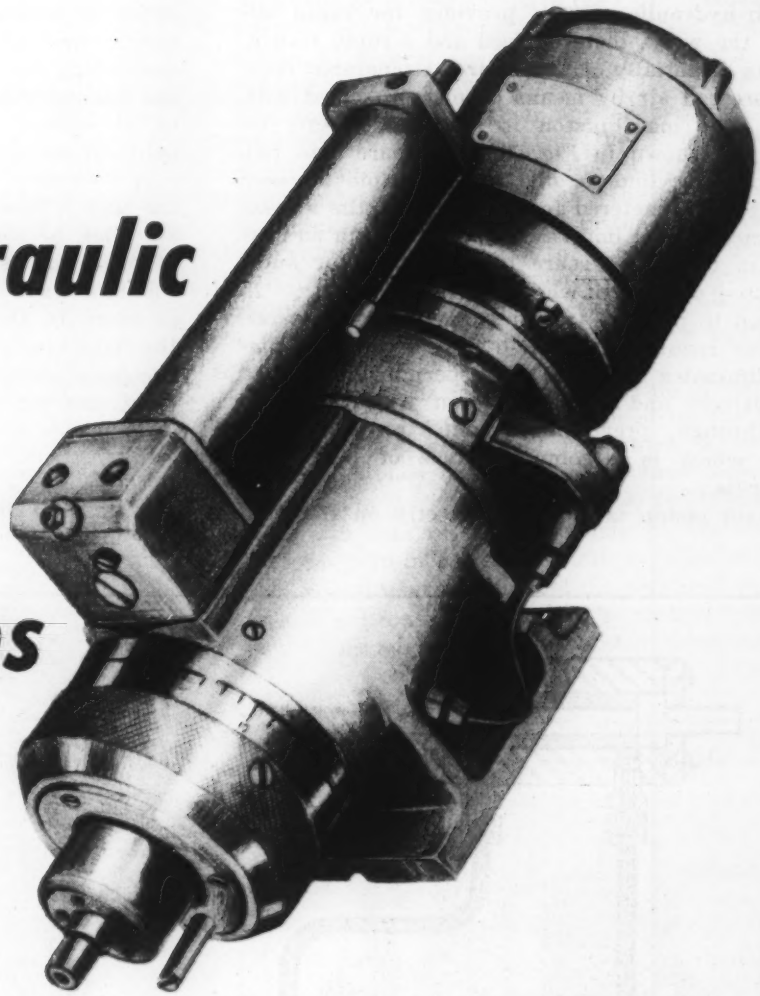
"If the student has acquired in college appropriate basic knowledge and a mind trained in its use, particular knowledge can with reasonable facility be acquired after graduation at the time of need"—ELLIOTT DUNLAP SMITH, *provost and Maurice Falk professor, Carnegie Institute of Technology.*

"Engineers, no less than the military, need more than ever to be on the alert in doubtful times—even to the point where peacetime commercial necessity may be subordinated to the overall conservation of strategic materials. In the last war, we were constantly troubled by the existence of peacetime designs that bore no relation whatsoever to the emergency, steel castings should have been drop forgings, parts made from solid bar instead of drawn or pressed, and an over-abundant and unnecessary use of alloys that were certain to be in short supply. Substitutes should be kept in mind or even indicated on drawings. Reasonable and sensible tolerance limits will extend the life of tools and gages, conserve materials, and shorten the hours of productive labor needed."—WILLIAM L. BATT, *SKF Industries.*

"To keep out of a rut, draw new and inexperienced minds into a problem. Almost invariably the person who didn't know it couldn't be done just goes ahead and does it."—FRED E. HARRELL, *Manufacturing Vice Pres., Reliance Electric & Engrg. Co.*

"Too often, young employees who are capable in other respects cannot set down their ideas in succinct and forceful English. It is a serious handicap because, however good ideas may be, they are worthless unless we can sell them to other people."—DR. FRANK M. SURFACE, *Consultant to Standard Oil Co.*

Air-Hydraulic System Simplifies Design



By Clarence Johnson
Consulting Engineer
Cleveland, Ohio

By the ingenious use of compressed air in conjunction with a hydraulic control system, many of the advantages of a hydraulic feed system without its complications are realized in the unique design illustrated in *Fig.* 1 and in the illustration on this page. Developed in several sizes by Cleveland Republic Tool Corp. as a universal manufacturing unit, it may be used for milling, drilling, or boring. Primary requirements were flexibility in operation, structural rigidity, high accuracy, ample power, and compactness, all at a reasonable cost.

In developing the design it was felt that the only way to attain this goal was to strive for the utmost simplicity. The air-hydraulic system which was evolved has made possible the realization of this objective, there being only one major moving part in addition to the spindle. Positive stops rather than

moving valves, cams or levers control the motion.

The air-hydraulic system provides for rapid advance to the work, metered feed and a rapid return. It consists essentially of an oil circuit separated from the compressed air by means of pistons sealed with O-rings. The main piston is mounted directly on the quill, as shown in *Fig.* 1. There are also two small receiver cylinders, one for the rapid advance and one for the metered feed portions of the stroke. Oil pressure is also impressed upon a switch so that changes in the oil pressure may be used for automatic cycling of the unit when desired.

Designed to produce two or three times the maximum force required, the air-hydraulic system completely eliminates backlash. This permits the unit to feed positively and uniformly even when the drill breaks through, preventing "jump" on the break through, which is a common cause of burrs and broken drills.

The main piston is mounted directly on the quill so as to insure concentricity of loading on the quill, which is supported on two heavy bearing surfaces spaced well apart. The adjustable position stop for controlling the depth of the hole is a heavy internal nut against which the piston comes to rest at the end of its stroke. The stop is clamped by means of a split nut construction.

A four-way valve controls the compresed air to the unit. This valve may be operated by hand, foot, air pilot, or solenoid. Referring to *Fig.* 1, the cycle of operation is as follows: On the working stroke the four-way valve is moved to the right to apply pressure to the light brown circuit and exhausting the light blue circuit. Air pressure builds up against the main piston and causes it to move rapidly to the right, forcing oil through the free passages to the

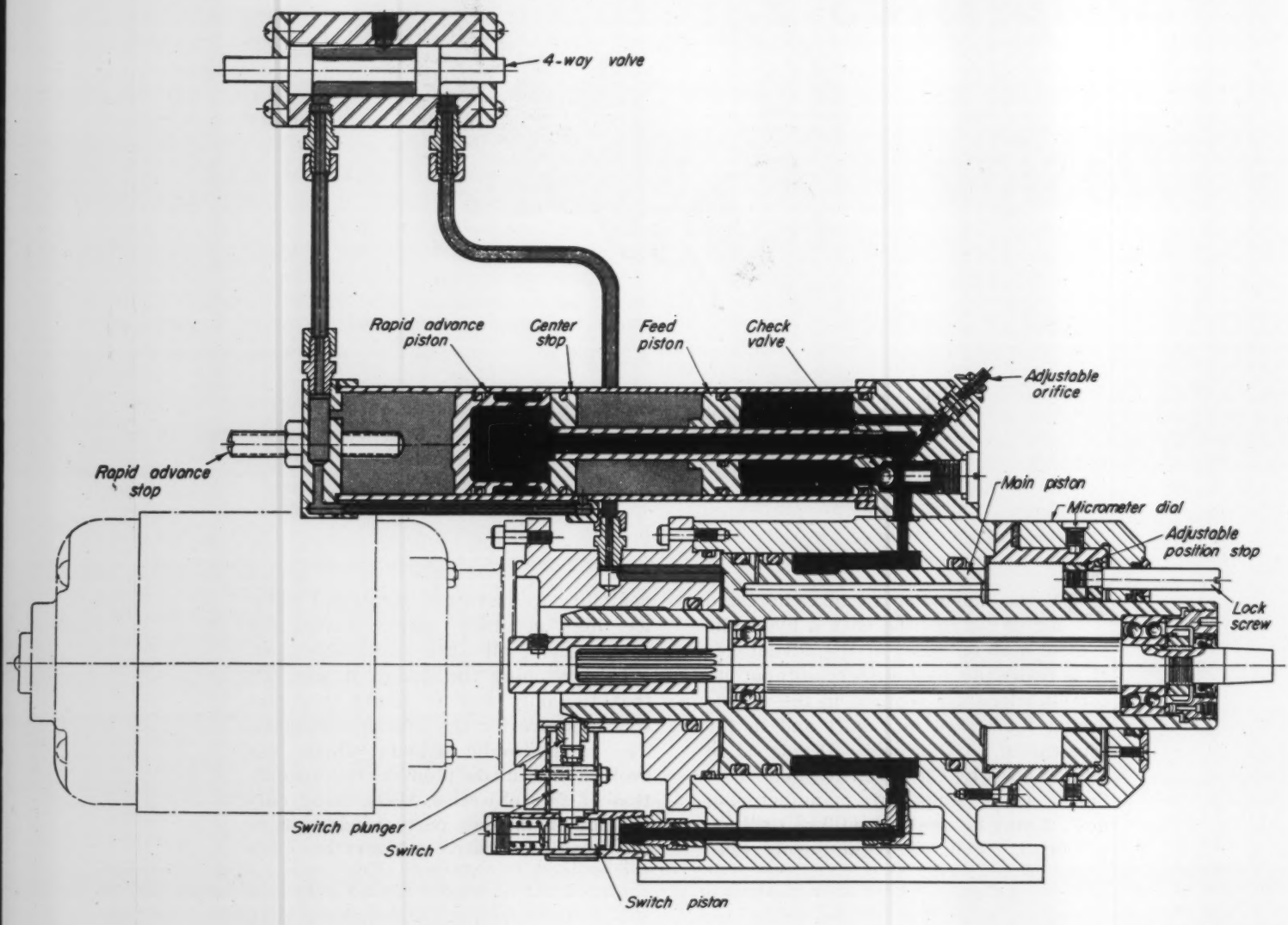


Fig. 1—Cross section through air-hydraulic power unit. Hydraulic circuit is shown in dark blue, air circuits in light blue and light brown

rapid advance piston and driving it against the rapid advance stop. This movement of the main piston also builds up the oil pressure somewhat and drives the switch piston to the left to maintain the electrical circuit, if this is incorporated into the system.

When the rapid advance piston hits its stop, the oil pressure builds up instantly and oil begins to meter through the adjustable orifice. The main piston continues to move to the right but at the controlled rate. Oil passing through the adjustable orifice also moves the feed piston to the left. The main piston continues to move to the right until it hits the adjustable-position stop nut. Oil pressure then drops and the switch piston moves to the right, breaking the electrical circuit through the switch and causing a solenoid to reverse the four-way valve back to the left-hand position shown in *Fig.* 1.

The four-way valve then applies pressure to the light blue circuit and exhausts the light brown circuit. Compressed air forces the rapid advance piston against the center stop, and the oil that was in this chamber returns the main piston part way. The check valve then opens and the feed piston moves to the right until the main piston has returned completely. As the main piston returns, the rear end of the quill moves the switch plunger which again energizes the electrical circuit.

The rapid approach travels at the rate of 200 inches per minute, the feed being controlled by the adjustable orifice, the adjustment for which is visible in the external view on Page 149. Three orifice sizes give speeds of 0 to 25, 0 to 50 and 0 to 75 inches per minute. In rate of feed this may be translated to 0.0005 to 1/16-inch per revolution. The rapid approach adjustment will control the length of the rapid approach portions of the stroke to within 0.005-inch.

The micrometer stop is graduated in thousandths.

Fig. 2—Vertical centering machine which simultaneously drills both ends of a part. Each of the two power units has 1¼-in. total stroke and employs a 1/3-hp motor

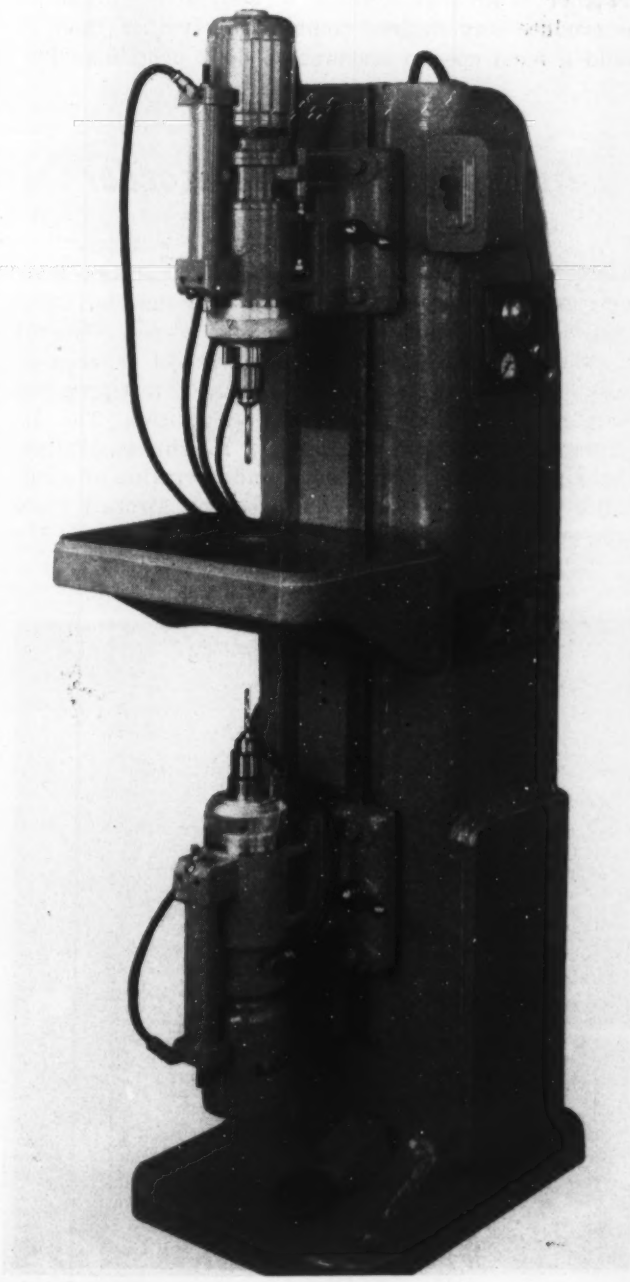
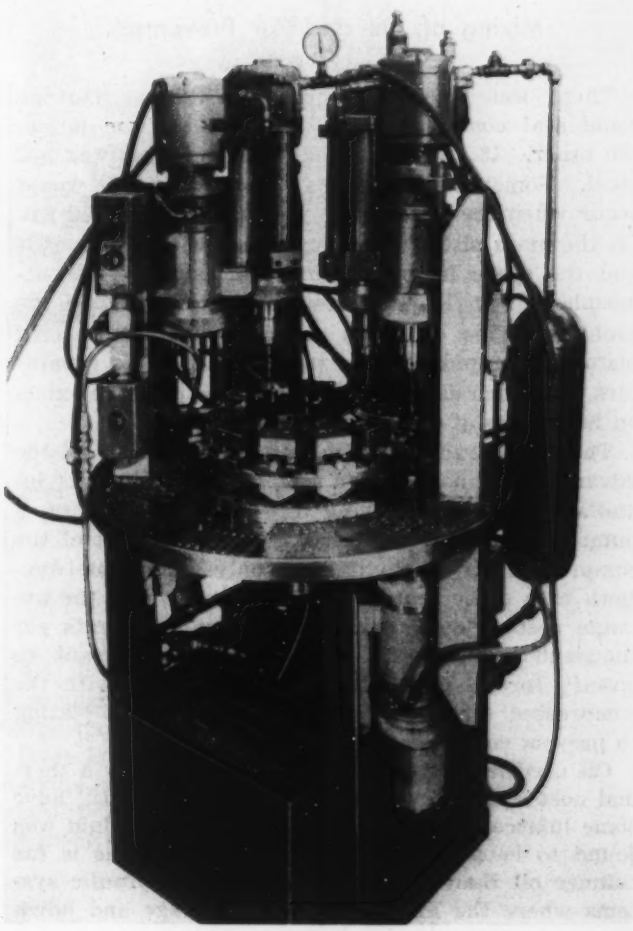


Fig. 3—Four-station, multiple-head drilling and countersinking machine employing five air-hydraulic units



It will hold the depth of hole to 0.0005-inch without difficulty. A slight dwell at the end of the stroke of 5 to 10 revolutions insures clean up and elimination of spring back from tool and work pieces. The spindle is driven by a ¼, 1/3 or ½-horsepower motor, either direct connected as shown in *Fig.* 1, or through a gear reduction or pulley drive. The cylinder for the feed piston holds about 100 per cent excess capacity of oil, to compensate for leakage over a period of time. It is easily refilled with the unit in any position by means of an oil gun. One filling is adequate for 500,000 to 1,000,000 cycles of operation.

The design incorporates a number of features based upon previous experiences and upon extensive series of experiments conducted with the first models. While there is considerable information available on O-rings for high-pressure oil, very little seems available on low-pressure oil and compressed air. The maximum pressure on the oil side is about 275 psi. It was found that the finish was just as important to the life of the O-ring at these low pressures as at high pressures. The main body is Meehanite cast iron bored, ground and polished oversize, then built up with chrome plate and finally honed to size with a mirror finish. The steel-tube rapid advance and feed pistons are finished the same way except when made from 18-8 stainless steel. Honing to a mirror finish alone is then satisfactory. Chrome flashing alone was found to be highly unsatisfactory.

Mixing of Oil and Air Prevented

There was also some question whether O-rings could seal compressed air on one side from oil on the other. It was found that this condition was not ideal. Sometimes a small air leak in the oil would occur when the differential pressure exceeded 50 psi. On the main piston, therefore, two O-rings were used and the space between them was vented to the atmosphere, *Fig.* 1. This design completely solved the problem. This condition did not exist on the feed piston and rapid advance piston that act as separators, inasmuch as practically the same pressure exists on both sides of the O-rings.

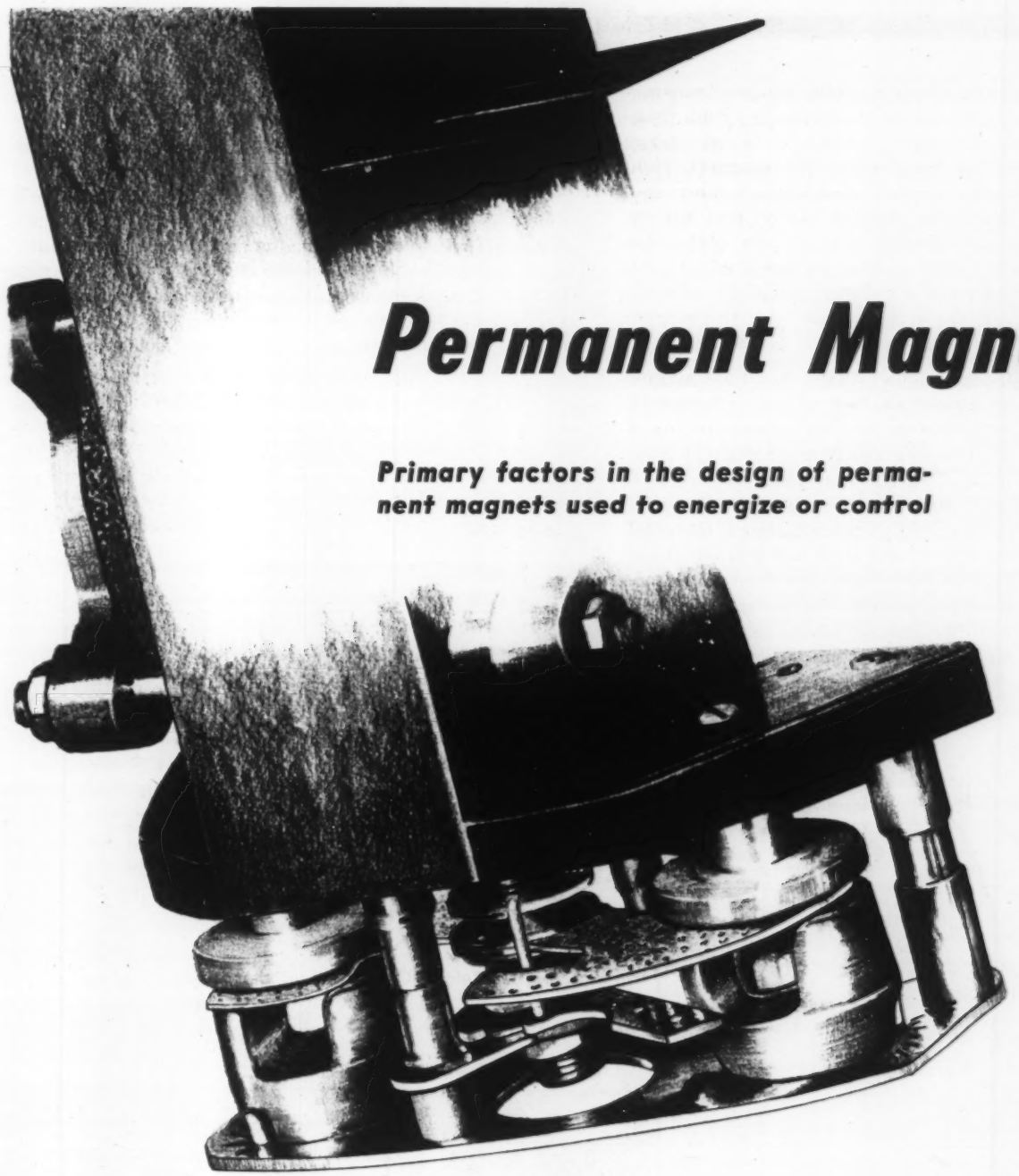
The air-hydraulic system was found to have all the advantages of a hydraulic system for this type of installation without having the complications of a pump, oil sump, relief valve, filters, etc. Cost of the compressed air is slight since only about one-twentieth of a cubic foot is used per stroke, and the average cost of compressed air is about six cents per thousand cubic feet. It was found important to specify for all parts that come in contact with the compressed air either stainless materials or plating to prevent corrosion from moisture.

Oil used in this service should have as low a thermal coefficient of viscosity as possible and still have some lubricating value. Aircraft hydraulic fluid was found to be satisfactory in every way. This is far thinner oil than is usually used with hydraulic systems where the limit is found in leakage and lubrication of pump, valves, etc. This oil has very little tendency to leak past the O-rings, and there is no heating of the oil as in a straight hydraulic system. The result is that there is little change in the speed of the controls from cold start until warm.

How the power unit is applied is illustrated by *Figs.* 2 and 3. *Fig.* 2 shows a vertical centering machine which simultaneously drills both ends of a shaft or rotor. *Fig.* 3 shows a four-station multiple-head drilling and countersinking machine for chain pins. It will be noted that the last station (on the right) has two units, one above and one below, to countersink both ends of the drilled holes simultaneously. The air accumulator at the extreme right of *Fig.* 3 serves to maintain uniform air pressure at the four-way valves. It is located between the 80-psi pressure-reducing valve and the four-way valves. These two applications are typical of many which permit the designer to arrange a series of standard units so as to produce any desired combination, rather than to build a fixed special machine to do a particular job.

Automatic Flight Recorder

EXPECTED to provide commercial airlines with increased information on flight operations and make possible greater operational control, a new General Electric flight recorder is being installed experimentally on a Capital Airlines DC-3 under a test program directed by the Air Transport Association. The instrument automatically records air roughness, altitude changes in 10-foot increments, and operation of automatic pilot and de-icing equipment on aircraft from take-off to landing.



Permanent Magnets

Primary factors in the design of permanent magnets used to energize or control

By James R. Ireland

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MODERN high-energy permanent-magnet alloys can often replace wire-wound electromagnets with many resultant savings. Among the advantages to be gained are: (1) No external power source required to maintain the magnetic field; (2) No temperature rise since there is no electric current flowing; (3) No fire or explosion hazard; (4) Uninterrupted service regardless of power failures or voltage variations; and (5) Portability of apparatus.

The functions performed by magnets in mechanical devices fall into three

general classifications: Attraction, torque transmission, and voltage generation. In designing such magnet-actuated or controlled units it is necessary first to determine the strength of the magnetic field required to give the desired performance and, secondly, to determine the magnet alloy and dimensions required to produce this field. Where space considerations permit, it is, of course, desirable to design the magnet to be of maximum magnetic efficiency. Often, however, the area available for the magnet is such that lower efficiencies are necessary.

GENERAL MAGNET DESIGN: The familiar magnetization curve and hysteresis loop of a ferromagnetic material are shown in *Fig.* 1. The horizontal or H axis represents magnetizing (or demagnetizing) force per unit length applied to the material. The vertical or B axis represents flux per unit area in the material.

Starting with an initially demagnetized material, represented by the origin, and applying a magnetizing force up to H maximum, causes the flux density to rise from zero to B maximum. Reducing this magnetizing force to zero causes the flux density to drop from B_{max} to Br (residual induction). Applying a negative H reduces the flux density from Br until it reaches zero with a negative H equal to Hc (coercive force) applied. Further increase of this negative H causes the flux density to reverse direction until it is $-B_{max}$ at $-H_{max}$. The curve follows a similar path from $-B_{max}$ to $+B_{max}$ and the closed loop thus formed is known as the hysteresis loop.

The portion of the curve of interest to magnet designers is that portion from Br to $-Hc$, which is shown in the left half of *Fig.* 2. The right half of this figure shows the product of B and H plotted

Nomenclature

Bm = Flux density in the magnet
Bg = Flux density in the air gap
Hm = The H co-ordinate on the demagnetizing curve corresponding to Bm
Am = Cross-sectional area of magnet measured at right angles to flux direction
Ag = Cross-sectional area of air gap measured at right angles to flux direction
Lm = Length of magnet measured parallel to flux direction
Lg = Length of air gap measured parallel to flux direction
f = "Reluctance factor" which varies from 1.1 to 1.4 normally; 1.3 generally used in design
F = "Leakage factor" which varies between about 1.5 to very large values depending upon the circuit. Both experience and considerable mathematics are required to estimate F closely.

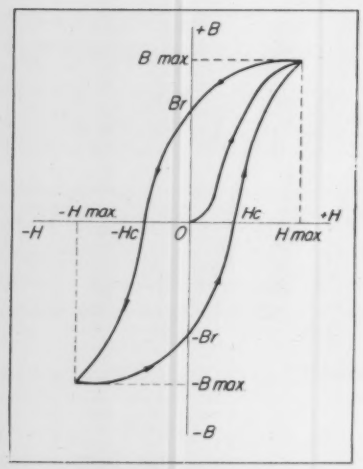


Fig. 1—Left—Typical magnetization curve and hysteresis loop of ferromagnetic material

Fig. 2—Below—Portion of hysteresis loop (Fig. 1) from Br to −Hc is of greatest interest to magnet designers. Curve at right, at BH_{max} indicates maximum magnetic energy which unit volume of material can maintain in air gap

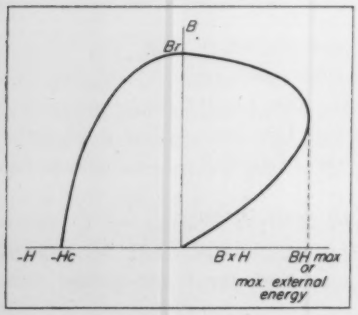
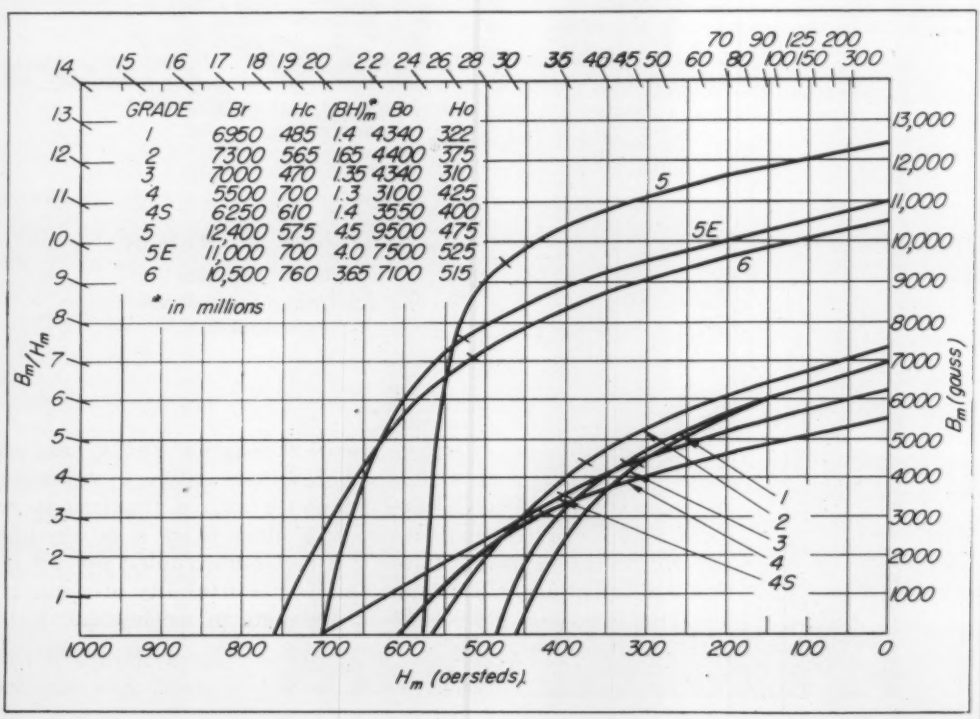


Fig. 3—Below—Characteristic demagnetization curves for various grades of Alnico



against B. The maximum value of this quantity is known as BH_{max} and is a criterion of the maximum magnetic energy which a unit volume of the material can maintain in an air gap. It is conventional in magnet design to ignore the negative sign of H, so the remainder of this article will deal with Hm, which indicates the H exerted by the magnet. Bm will mean the flux density in the magnet.

Characteristic demagnetization curves for various grades of Alnico are shown in *Fig.* 3. Curves for magnet steels and special alloys can be obtained from the catalogs of permanent magnet manufacturers.

Useful magnets operate neither at Br nor Hc but at some point between them, preferably at $(BH)m$. The actual point of operation is determined by the proportions, not the size, of the circuit. That is to say, two magnets that are geometrically similar will operate at the same point even though one may weigh thousands of times as much as the other.

A quantity known as Bm/Hm is determined by methods to be discussed later. A line with this slope is laid out from the origin and the point of intersection of this line with the demagnetization curve is noted. This is the operating point and the flux density in the magnet is the B co-ordinate of this point. Bm/Hm is dependent upon shape, not upon the material, so that different materials may be compared rapidly once Bm/Hm has been determined. In *Fig.* 3, for convenience, Bm/Hm has been plotted as dashed lines around the border of the graph. If Bm/Hm is 20, for example, a straight edge would be laid from the origin (0) to the dashed line marked 20. To have the magnet operate at $(BH)m$, Bm/Hm for the various Alnicos must be about as follows:

Alnico 1	13.50	Alnico 4S	9.00
Alnico 2	11.75	Alnico 5	20.00
Alnico 3	14.00	Alnico 5E	14.30
Alnico 4	7.30	Alnico 6	13.80

OPEN-CIRCUIT MAGNETS: An open-circuit magnet is one containing no iron pole pieces or other magnetic attachments and which has been magnetized, then removed from close proximity to magnetic materials or fields.

For an open-circuit straight bar magnet of round cross section, Bm/Hm is determined by the ratio of length to diameter. *Fig.* 4 shows the relation between these two. From this curve, if L/D is known, Bm/Hm can be determined. For straight bars of other than round cross-section, this curve can be used by con-

Fig. 4--Curve gives relationship of length/diameter ratio to Bm/Hm ratio for round open-circuit straight bar magnets

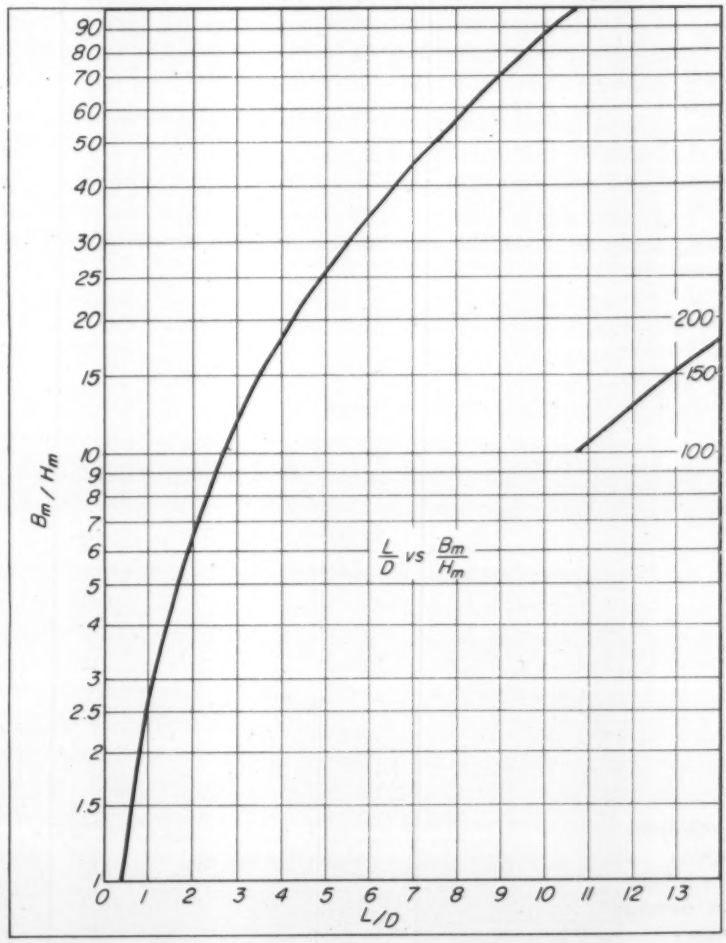
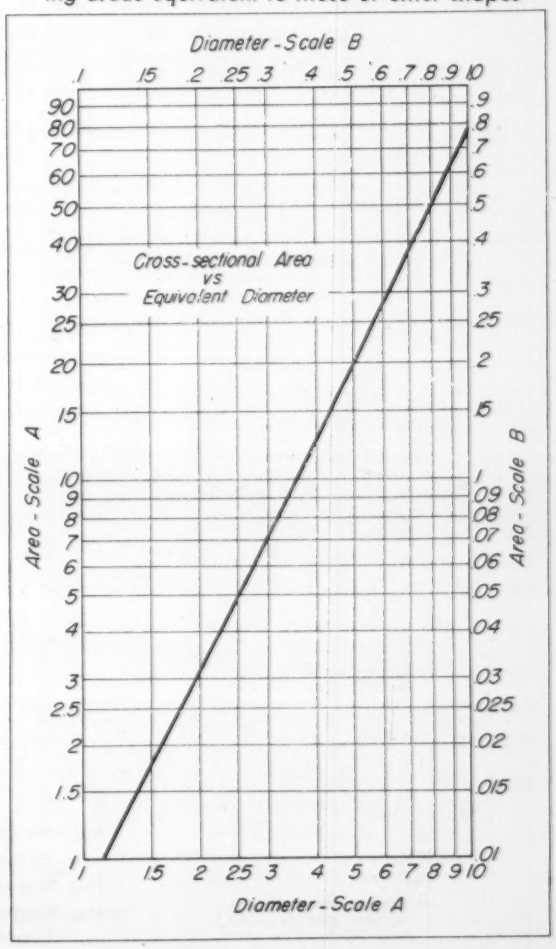


Fig. 5—Curve gives diameters of round bars having areas equivalent to those of other shapes



verting the actual cross-sectional area to the diameter of an equivalent circle by the formula

$$D = \sqrt{\frac{4}{\pi} \times \text{Area}}$$

For convenience, *Fig.* 5 has been plotted showing the relation between area and equivalent diameter. Values can be picked directly from this curve, eliminating the need for calculation.

Figs. 4 and 5 can be used for other than straight bar magnets. *Fig.* 6 shows other magnet shapes and the methods of calculating L and D so that Bm/Hm can be determined from *Fig.* 5. Extreme accuracy cannot be expected from these methods, but they are sufficiently close for ordinary use.

CLOSED-CIRCUIT MAGNETS: A close-circuit magnet is one which is magnetized in an assembly containing soft iron or other magnetically soft materia, and which is not subsequently removed from that assembly. Normally, such an assembly will contain an air gap.

For predicting the performance of an assembly, the following may be used:

$$\frac{Bm}{Hm} = \frac{F \times Ag \times Lm}{f \times Am \times Lg}$$

Bm/Hm is used in the same manner as previously described. Having determined Bm by laying out a line from the origin with slope Bm/Hm and noting its intersection with the demagnetization curve of the material, the flux density in the air gap can be determined as follows:

$$Bg = \frac{Bm \times Am}{F \times Ag}$$

To design a new assembly, the air gap dimensions and flux density requirements of which have already been determined, the following is used:

$$Am = \frac{F \times Bg \times Ag}{Bo}$$

where $Bo = Bm$ at the $(BH)m$ point;

$$Lm = \frac{f \times Bg \times Lg}{Ho}$$

where $Ho = Hm$ at the $(BH)m$ point.

This automatically gives the most efficient magnet possible. In the equations used in this section, either the English or Metric system of measurement may be used, but not, of course, a mixture of the two. However, the Metric system only may be used in these:

Total flux supplied by magnet $= Bm \times Am$
Total flux in the air gap $= Bg \times Ag$

Magnets subject to demagnetizing force or open circuiting may be figured as follows: Refer to *Fig.* 7 and assume that line OA represents Bm/Hm for the magnet after magnetizing in the assembly. If the magnet is subjected to a demagnetizing force, Hs, the operating point of the magnet will travel down the curve from A to B. Upon removal of the demagnetizing force, the operating point does not travel back up to A, but instead moves up a minor hysteresis loop until it intersects line OA at C; C then being

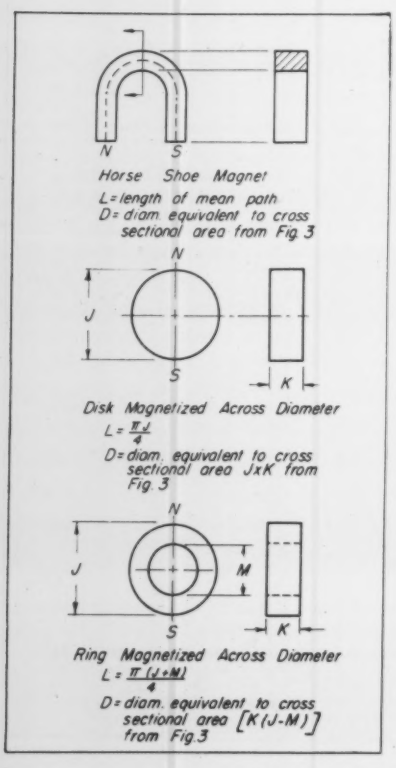


Fig. 6—Left—How L and D are calculated for magnets of various shapes, permitting determination of Bm/Hm applying to them from curve of Fig. 4

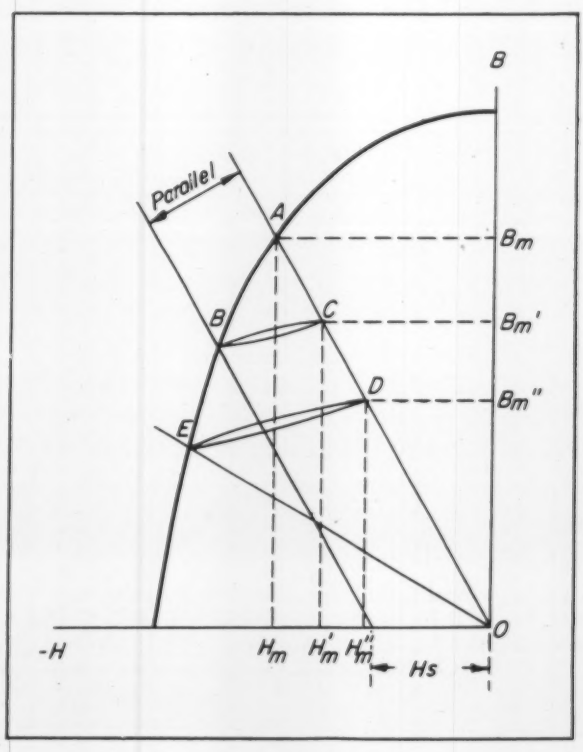


Fig. 7—Right—Graphical determination of flux loss due to subjecting magnet to demagnetization

the new operating point. The magnet has now suffered a permanent loss of flux (equal to $Bm - Bm'$). However, it is now stabilized—that is, it can undergo demagnetization up to the magnitude of Hs without losing any further flux. It travels back and forth on the minor loop and upon removal of the adverse field, will always return to point C for all practical purposes. Theoretically, each time it will asymptotically approach some point slightly below C but this is a negligible consideration.

The same phenomenon takes place if the magnet is open circuited. The operating point moves from A to the intersection of the new operating line, OE, and the curve. Line OE represents Bm/Hm for the open-circuit magnet. If the magnet is replaced in the assembly, the operating point moves up a minor loop, ED, in a manner similar to that described in the preceding paragraph. The slope of the minor loop is about the same as the slope of the demagnetization curve at the Br point.

Design Simple if Flux Density Is Known

It will be noted from this discussion that the design of magnets is a simple affair (except for estimating F) if the air gap dimensions and desired flux density are known. However, in nine cases out of ten, the desired flux density is not known, only the performance of the finished article being given in the specifications.

Examples are: Holding power against a steel armature, voltage and current from a generator, torque and/or speed of a motor, torque of a hysteresis drag unit, and damping coefficient of an eddy-current damper. In such cases, the main problem is the calculation of the flux necessary to do the desired job; designing a magnet to produce this flux being simple in comparison.

This leads to a discussion of the methods of figuring the amount of magnetic field and its arrangement to perform specific jobs. Almost always permanent magnet curves are plotted in metric units (B in gauss, H in oersteds). Consequently, in all formulas containing these terms, they will be expressed in these units. All linear dimensions, areas, torque, or force will be expressed in English units, however, and the formulas will contain appropriate conversion constants.

ATTRACTION: The earliest noted property of magnets was their attraction for iron or for the opposite pole of another magnet. This quality of a permanent magnet is still used in innumerable types of apparatus. In control equipment, however, the most common application is for switches. Here the magnet assures a positive make and break with a minimum of arcing. The photograph of *Fig.* 8 illustrates a switch of this type.

Attraction can also be utilized to actuate a device through a seal, thus eliminating packing glands and the like. *Fig.* 9 illustrates a float switch. The float actuates a steel slug which rides up and down in a nonmagnetic tube. When the iron slug reaches a certain level, the magnet's attraction for the iron causes the magnet to swing in close to the tube, thus tilting a mercury switch to start any desired electrical action.

Attraction of a magnet for an iron object a short

Fig. 8—Below—Utilization of attraction property of permanent magnet to effect positive make and break of switch with minimum of arcing (photo, courtesy Penn Electric Switch Co., Goshen, Ind.)

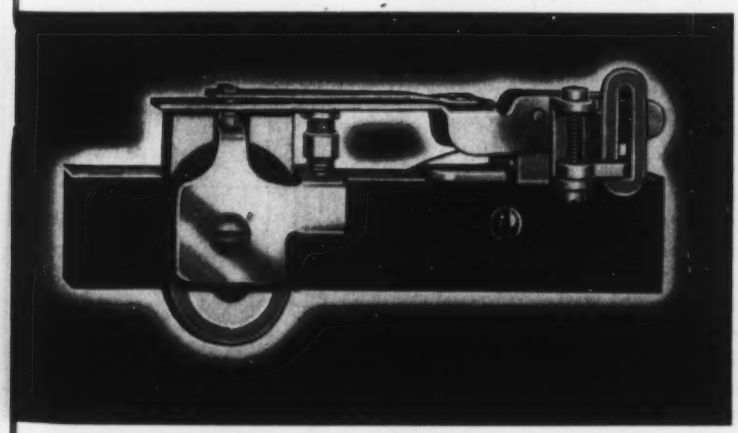
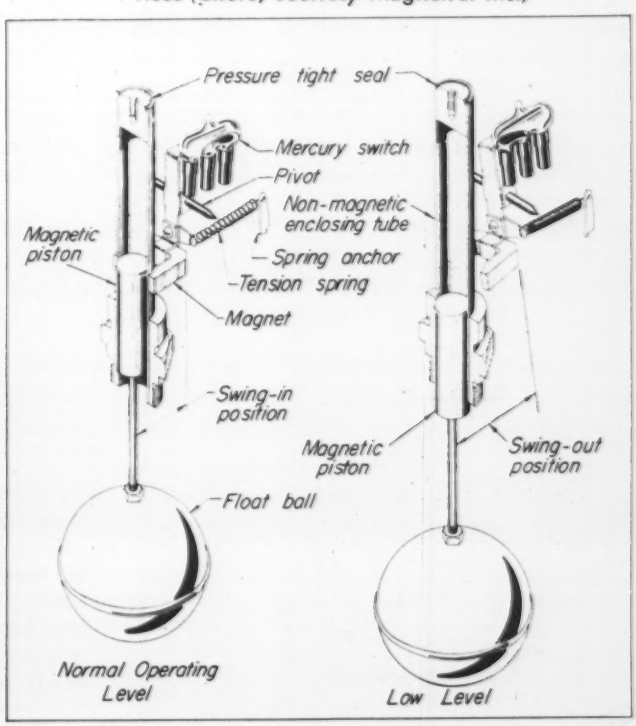


Fig. 9—Below—Magnetic attraction is employed to actuate mercury switch in relationship to position of float ball. With float-ball piston at normal level, magnet is drawn by piston to enclosing tube. This action tilts the mercury switch so that its middle and right-hand legs are connected. When float ball lowers, its piston moves away from the magnet, which is pulled away from tube by spring. This action tilts mercury switch so that its left-hand and middle legs are connected. Principle can be utilized on many devices (photo, courtesy Magnetrol Inc.)



distance from its poles can be reduced almost to zero by the introduction of another piece of iron between the poles. This is known as "shorting" the poles, and can be used to "turn off" the magnet and cause it to release the object it is holding.

Another common use for the attraction of a magnet to other ferromagnetic materials is in the field of magnetic separators, wherein the magnet separates out any extraneous iron particles from a nonmagnetic material. The separator is usually placed in the feed chute leading into a machine. A variation of these devices is used to remove metal particles from coolant. Here the arrangement generally is such that the magnetic particles being removed form a screen to eliminate abrasive and other nonmagnetic particles. Vending machines use magnets to eliminate iron slugs. The magnets also separate nonmagnetic slugs from good coins by a method to be described later.

In designing magnets for attraction uses, it is obviously necessary to be able to compute the force exerted. Two parallel surfaces, between which lines of force are passing at right angles to the surfaces, will experience a force tending to hold or pull them together. The magnitude of this force in pounds is equal to

$$5.77 \times 10^{-7} \times B^2A$$

where:

B = flux density in gauss

A = area in square inches of flux path measured normal to flux direction.

To design a simple horseshoe magnet to provide a pull on a steel armature in contact with the poles, the length-to-diameter ratio should be chosen so that the magnet will operate, open circuit, near the $(BH)m$ point of the alloy chosen. The pull against the armature is figured, with fair accuracy, as follows: First, on the curve for the material, mark the operating point of the open-circuit magnet. When the magnet contacts the armature, practically no air gap may be assumed. Next, draw a line from the open-circuit operating point with a slope equal to the slope of the curve at the Br point (this, then, represents a minor loop). Prolong this line until it meets the "B" axis and note the B at that point. Divide this B by about 1.7 (which represents the leakage factor and certain other factors). Use this figure for B in the equation previously given for pull. (Do not forget to use the area of *both* poles for A.)

Pull of a magnet at fairly large distances from an armature cannot be calculated by any simple means because of the large number of variables involved. For instance, two magnets, one with a large pole gap and one with a small pole gap may have the same pull when in contact with the iron. A short distance away from the iron, however, the one with the narrow pole gap will have considerably less pull than the other one.

Holding fixtures containing both iron and a magnet may be figured in a manner similar to that described for a horseshoe magnet, the difference being that the first step involves calculating the operating point of the magnet as magnetized in the assembly rather than open-circuit. As before, the assembly should be designed so that the magnet operates near $(BH)m$ before the pole pieces contact the iron armature which they are to hold. The essential details of such an assembly are illustrated in *Fig.* 10. Here, A is the sum of the cross-sectional areas of the two iron pole pieces at the point of contact with the object being held. As previously, Bm is the B ordinate at the point where the minor loop intersects the "B" axis. The B to be used in the force formula previously given is then:

$$B = \frac{2BmAm}{FA}$$

where F = the leakage factor—about 1.7—and A is as mentioned in the immediate foregoing. Consequently, substituting in all appropriate values, the pull against the object being held is, in pounds, figured as follows:

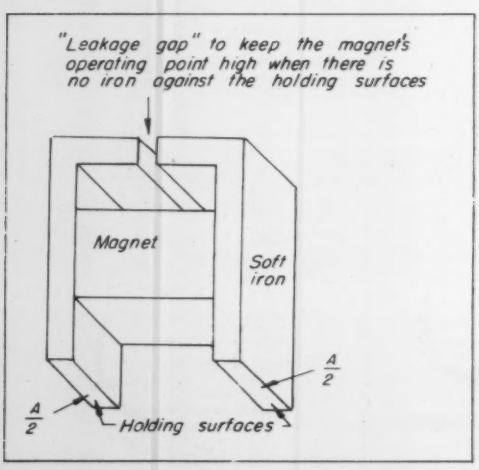


Fig. 10—Left — Primary details of a permanent-magnet "holding" unit

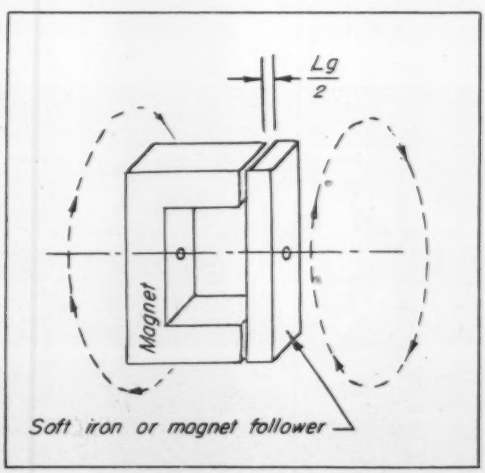


Fig. 11—Right — In follower type torque-transmitting system, follower member rotates in unison with magnet. Lag between members is in proportion to magnitude of torque being transmitted

$$23.08 \times 10^{-7} \frac{Bm^2 Am^2}{F^2 A}$$

TORQUE: The ability of a magnet to transmit torque without any mechanical connection finds wide use for varied applications. The arrangements for accomplishing this may be classified under three main systems: Follower systems, hysteresis systems, and eddy-current systems.

Follower systems operate in principle as illustrated schematically in *Fig.* 11. Main feature of this arrangement is rotation of the magnet and follower (which may be another magnet or soft iron) at the same speed. The greater the torque, the greater is the angular displacement between the two. If the torque is too great, the follower slips out of synchronism and practically no torque can be transmitted until the two are synchronized again. In this they are analogous to synchronous motors.

One common use for this set-up is as a position indicator through a seal. For instance, the level of fluid in a tank can be indicated by means of a float which rotates a magnet. The follower on the outside of the tank will then follow the magnet's rotation and indicate the level. Of course the tank wall between the magnet and follower must be nonmagnetic. The same arrangement has been used to transmit the reading of gas meters without a mechanical connection. There are many other similar applications, among which is the magnetic mixer which appeared recently in one of the popular magazines.

Exact calculation of the torque at large angles of displacement is difficult for the same reasons as is the calculation of attraction with large air gaps. Further, the magnitudes will be different depending upon whether the follower is another magnet or soft iron. For small displacement angles, however, the torque may be approximated as follows:

$$\text{Torque (in-lb)} = 10^{-6} Bg^2 AgLm \sin\theta$$

where:

θ = angle of displacement between magnet and follower
Ag = area of gap in square inches
Lm = length of magnet in inches.

Hysteresis systems, the next general classification, are characterized by the ability of the magnet and hysteresis drag unit to rotate synchronously or out of synchronism with practically no change in their ability to transmit torque. In other words, the two will rotate at the same speed until the torque load becomes too great. They will then slip smoothly and without vibration, meanwhile maintaining constant torque between them. When the torque load is reduced again to the proper figure, they will again revolve synchronously. In this they act like a friction clutch (except that there is no wear, of course) and like hysteresis motors.

This arrangement is sometimes used in instruments and other apparatus for overload protection. *Fig.* 12 illustrates the principal essentials of such a device, showing two different methods. The maximum torque in inch-pounds which can be transmitted without slippage is given by:

$$\text{Torque} = .705\ hVP$$

where:

h = hysteresis loss in joules per cu. in. per cycle of the drag unit material. This figure is shown in TABLE I for some commonly used steels. The use of the "Bi" and "Hi" columns will be given later
V = volume of the drag unit in cu. in.
P = number of poles on the magnet.

The steps involved in designing for a given torque

Fig. 12—Below—Two methods of transmitting torque by utilization of hysteresis effect. These units rotate synchronously or nonsynchronously with practically no change in torque transmitting ability (piece to right of drag unit in cross section view may be a second magnet or soft iron rotating with the first magnet; or may be soft iron rotating with drag unit. In latter case, it may take the form of another ring and be fastened direct to drag unit)

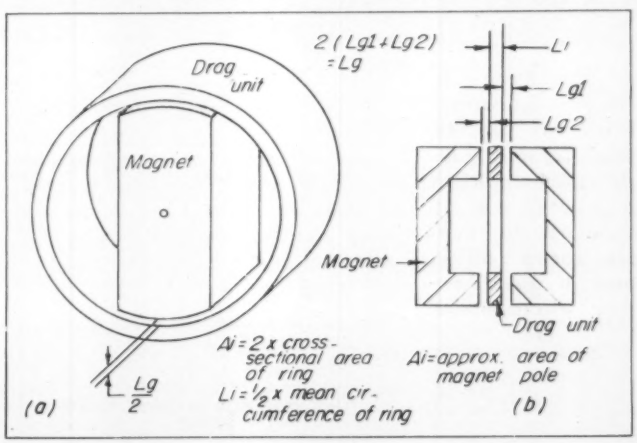
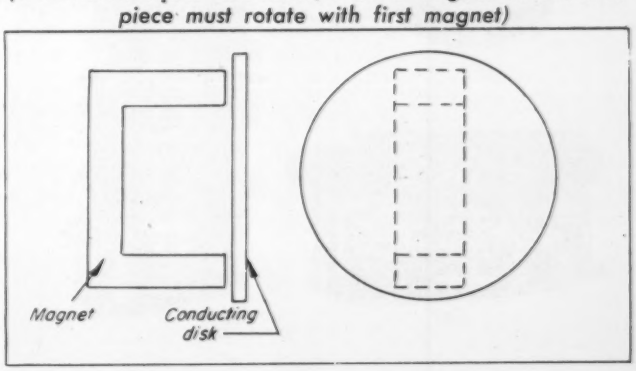


Fig. 13—Below—In eddy-current system of torque transmission, torque is directly proportoinal to the difference in angular velocity between the two members (arrangement shown in Fig. 12b can also be used by replacing drag unit with conducting disk to retain proportionality of speed and torque. However, second magnet or soft iron piece must rotate with first magnet)



are: First, set the dimensions and material of the drag unit and the number of magnet poles to obtain the desired torque as shown in the previous equation.

TABLE I—**Drag-Unit Material Characteristics**

Material	h	Bi	Hi
SAE 1020, half hard	0.045	15,000	50
2½% Chrome steel, hardened	0.40	14,000	400*
17% Cobalt steel, hardened	1.10	15,000	800*
37% Cobalt steel, hardened	1.45	15,000	1000*

* These are best used in the arrangement shown in *Fig.* 12*b*.

Secondly, if the magnet can be magnetized in the assembly, the area of the magnet in square inches is given by:

$$Am = \frac{F \times Bi \times Ai}{Bm}$$

where:

Bi = the nominal saturation induction for the steel chosen or hysteresis material used for the drag unit (TABLE I).

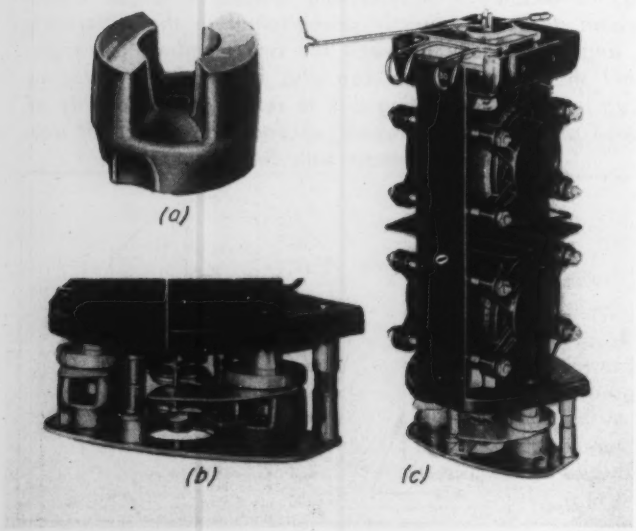
Ai = total cross section in square inches of the flux path in passing through the drag unit

Bm = B co-ordinate of the operating point of the permanent magnet material chosen. The operating point should be as close to $(BH)m$ as practical

F = Leakage factor.

Next, compute the air gap flux density as follows:

Fig. 14—Below—Eddy currents between moving vanes and permanent magnets provide adjustable damping of electrodynamometer instrument movement. Alnico 2 magnets (a) are cast with mounting holes cored and pointer nub at base cast to shape. Rotation of magnet changes position of poles with respect to moving vane (b). Thus, damping is adjusted to point of optimum operation. Complete measuring element of instrument is shown at (c)



$$Bg = \frac{Bm \times Am}{F \times Ag}$$

Using this figure, the length of the magnet will be:

$$Lm = \frac{(Bg \times Lg) + (Hi \times Li)}{Hm}$$

where:

Hm = H co-ordinate of operating point of permanent magnet material. Bm and Hm are simultaneous values of this point

Hi = that H required to approximately saturate the hysteresis material chosen for the drag unit (see "Hi" column of TABLE I)

Li = length of flux path in drag unit (see *Fig.* 12).

If the unit cannot be magnetized as a unit, then Bm/Hm for the open-circuit magnet is determined by methods previously given. When the drag unit is placed in position, the operating point moves up a minor loop as previously described.

Eddy-current systems, the last torque classification, have been in use for many years, the most familiar use probably being that of houshold watt-hour meters. The principle involved is the same as that of induction motors; that whenever there is relative motion between a conductor and a magnetic field, there are eddy currents induced in the former which in turn give rise to mechanical forces.

Schematic representation of such a unit is shown in *Fig.* 13. When either the magnet or conducting disk is rotated, there is a torque developed tending to rotate the other member. For a given setup, the torque developed is directly proportional to the difference in angular velocity between the two. In the watt-hour meter mentioned, a conducting disk rotates between the poles of a stationary permanent magnet, thus assuring that its speed of rotation is directly proportional to the torque applied.

How the Esterline-Angus Co. applies eddy currents to provide adjustable damping for some of their in-

(*Continued on Page* 224)

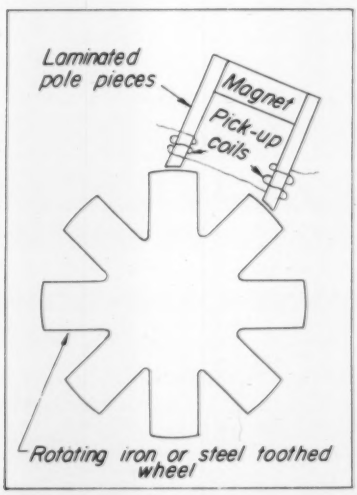
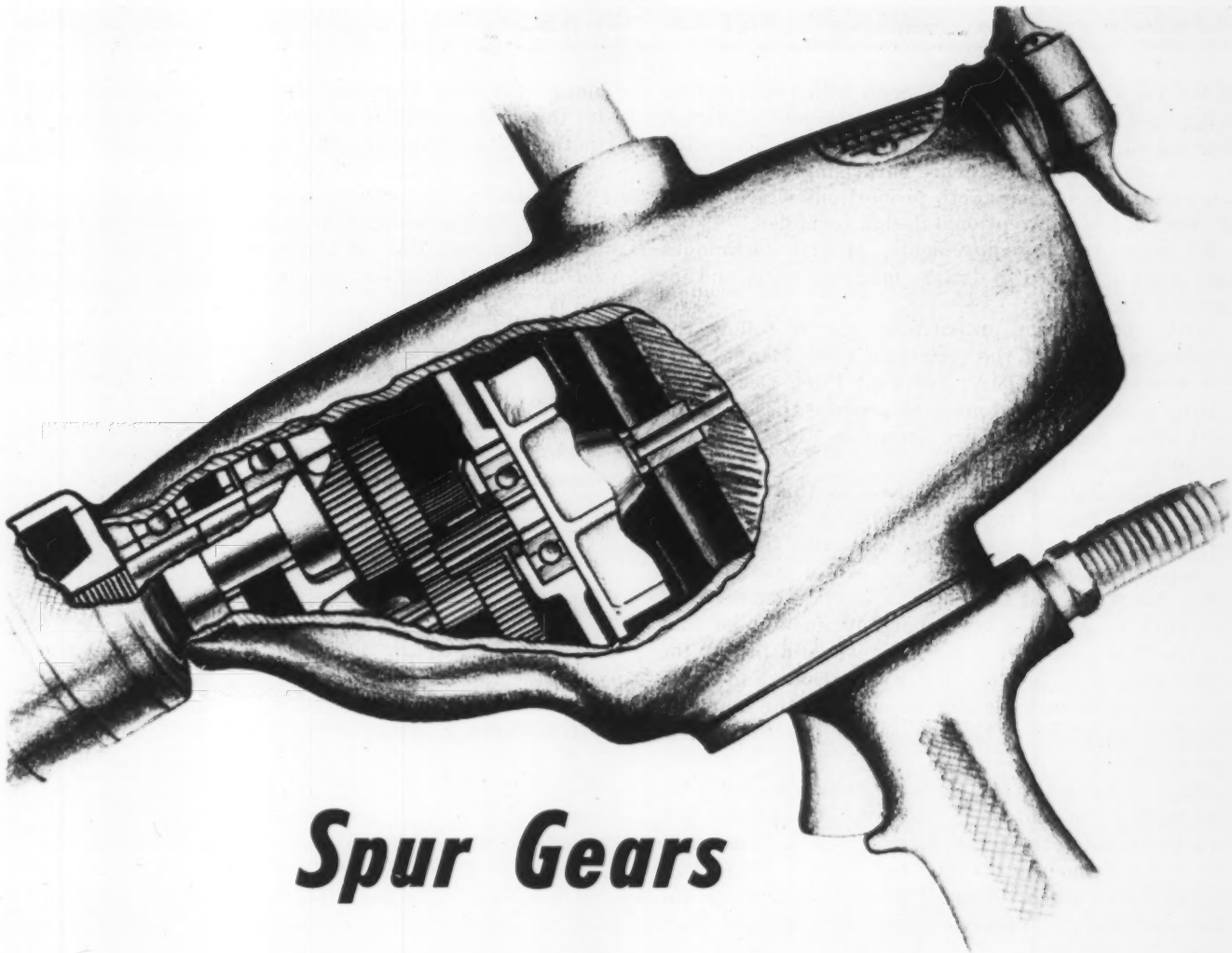


Fig. 15 — Right — In voltage - generator device, as toothed wheel rotates, voltage pulses picked up in coils can be employed to indicate speed, differences in speed, angular displacement, etc.



Spur Gears

. . . for use with universal and aircraft motors

By R. P. Loveland
Fractional Horsepower Motor Divisions
General Electric Co.
Fort Wayne, Ind.

IN DESIGNING spur gears for operation with universal and aircraft motors, several unusual factors affect the nature of the design. Motor speeds are usually high, ranging from 5,000 to 15,000 rpm at full load and attaining as much as 30,000 rpm at no load. Speed increases rapidly as load drops off and torque is high when starting under load, or with stalled conditions. Space is always at a premium and high reductions per stage are desired. Power requirements range from practically nothing to as much as thirty horsepower.

Usually the motor is a separate unit, supported on its own bearings and aligned with the mating gear housing by means of a pilot fit, with the driving pinion either cut on the motor shaft or mounted directly upon it, *Fig.* 1. Center distance variations will be dependent on the concentricity of the bearings and

of the pilot fits, the accuracy with which the mating center can be located, and the composite variation existing in each member of the gear set. Connected masses are usually low, hence surprisingly high loads can be carried on gear tooth proportions which would be ruled out by conventional design formulas.

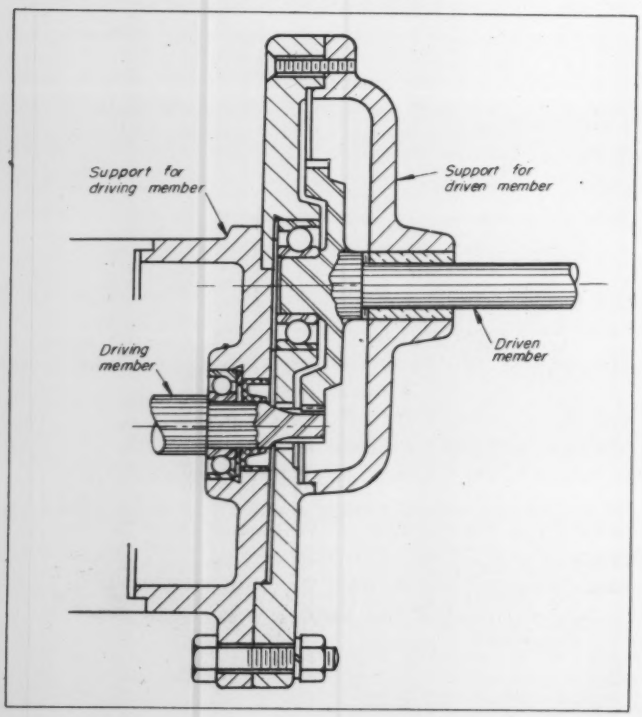
To meet these requirements, special techniques have been developed in design, manufacturing and inspection methods.

Basic tooth form proportions should follow the recommendations of the American Gear Manufacturer's Association (AGMA) for Fine Pitch Gears, and cutting tools should be made to produce these. Basic tooth form proportions are shown in *Fig.* 2, and actual dimensions in TABLE I.

Actual design proportions used in this work are those which result from machining the gear teeth a specified amount over or under size with these tools, by shortening or increasing the center distance between the work and the cutter. Outside diameter of the work is varied a corresponding amount so that the result is a part with the same whole depth as the active portion of the tool, but with a change in width at the pitch diameter which is equal to the diameter change multiplied by the tangent of the basic pressure angle.

Some designers refer to this change in size as a change in pitch diameter. However, the author prefers to consider the pitch diameter as a fixed value which is obtained by dividing the number of teeth by the diametral pitch. This is the circle at which the basic or "design" pressure angle occurs; also, it is along this path that the circular pitch corresponds to the design diametral pitch, and as the circular tooth width increases, the space between teeth decreases a like amount and vice versa.

Fig. 1—Typical design of gear reduction assembly for use with a series motor



Amount of the size change on the pinion is dependent on the number of teeth, primary consideration being reduction of undercutting. Under AGMA recommended practice, amount of diameter increase, Δ_d, is

$$\Delta_d = d\cos^2\phi + \frac{4}{P} - \frac{n+2}{P}$$

where d = pitch diameter; ϕ = design pressure angle; n = number of teeth on pinion; and P = diametral pitch. Then outside diameter, d_o, is

$$d_o = \frac{n+2}{P} + \Delta_d$$

or can be calculated directly as

$$d_o = d\cos^2\phi + \frac{4}{P}$$

Whole depth, h_t, is

$$h_t = \frac{2.2}{P} + 0.002\text{-inch}$$

for all pitches 20 and finer. For pitches coarser than 20,

$$h_t = \frac{2.157}{P}$$

Root diameter, d_r, is

$$d_r = d_o - 2h_t$$

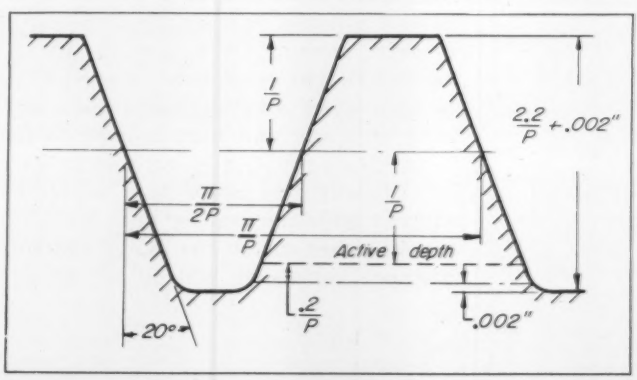
Change in circular tooth thickness at the pitch diameter, Δ_t, is

$$\Delta_t = \Delta_d \tan\phi$$

Then circular tooth thickness at the pitch diameter, t_s, is

$$t_s = t + \Delta_t$$

Fig. 2—Basic proportions of AGMA fine-pitch rack tooth



where t is basic circular tooth thickness, $\pi/2P$.

Amount of the diameter increase given in the foregoing for pinions is based on their engagement with a mating rack with no interference between the tip of the rack tooth and the root section of the pinion. It results in successively greater amounts of diameter increase as the number of teeth decreases, and starts at 17 teeth. If less than eight teeth are used, the involute arcs which form their sides will cross at a point somewhat lower than the foregoing formula for outside diameter indicates. This gives a pointed tooth with reduced outside diameter, which is not desirable but can be tolerated if a satisfactory contact ratio is obtained. It should be remembered that Δ_d is still obtained from the same formula and that circular tooth thickness t_δ is still determined in the same fashion.

To determine the diameter at point of tooth, d_p,

$$d_p = \frac{d \cos\phi}{\cos\phi_p}$$

where ϕ_p = pressure angle at point. The involute function of ϕ_p, is

$$\text{inv}\ \phi_p = \frac{t\delta}{d} + \text{inv}\ \phi$$

The function inv ϕ = tan ϕ − ϕ where ϕ is in radians.

Some authorities recommend machining the blank somewhat undersize to obtain a flat or "land" on the tooth tip but this still further decreases the contact ratio. The author has found that for this class of work a pointed tooth works quite well, but it is preferable to increase the number of teeth to at least eight when possible by using a finer pitch or by increasing center distance.

When pinions are hobbed to these proportions, a very small amount of undercut will still remain above the base circle unless the tip of the hob tooth is rounded sufficiently to eliminate it. If parts are cut by a circular shaper cutter, the amount of undercut will become less as the cutter diameter decreases, although it would be well to use at least as many teeth in the cutter as are present on the mating gear which will be employed. With rack type shaper cutters, the same is true as for hobbing. TABLE II lists the amount of undercut for representative pitches when using a sharp-pointed hob or rack type cutter.

The undercut below the base circle is quite pronounced but leaves sufficient tooth for strength and makes it possible to shave to the base circle without it being necessary to use special preshaving hobs, since no root fillet interference is encountered and the base circle is well above the root.

Illustrated in *Fig.* 3 are the proportions found on tooth forms when the number of teeth is sufficient to make the above practice unnecessary. This design has a twenty-tooth pinion and an eighty-tooth gear cut to standard proportions.

In *Fig.* 4 is shown what happens when the number of teeth on the pinion becomes less than eighteen (with other than 20-degree pressure angle the minimum number of teeth without undercutting changes) and the gear is still as in *Fig.* 3. This pinion has eight teeth and is cut to standard proportions.

Correctly proportioned parts for an eight-tooth pinion and eighty-tooth gear running on basic center distance are illustrated in *Fig.* 5. In order that this mating gear will mesh satisfactorily with the oversize pinion, it is cut undersize by the same amount. Thus outside diameter of mating gear is

$$D_o = \frac{N+2}{P} - \Delta_d$$

where N = number of teeth on mating gear. Root diameter becomes $D_r = D_o - 2h_t$, thus maintaining full depth as in the pinion. Circular tooth thickness at the pitch diameter is $T_\delta = T - \Delta_t$, where T = basic circular tooth thickness of gear, $\pi/2P$.

This practice works quite well until the number of teeth specified on the gear is so small that the reverse modification causes excessive undercutting. For example, *Fig.* 6 consists of an eight-tooth modified pinion and twenty-tooth mating gear modified in re-

TABLE I

Basic Rack Proportions for Spur Gears (20 degree pressure angle, AGMA fine-pitch system)

Diametral Pitch	Addendum	Dedendum	Whole Depth	Double Depth	Circular Pitch	Tooth Thickness
20	.0500000	.0620000	.1120000	.2240000	.1570796	.0785398
22	.0454545	.0565455	.1020000	.2040000	.1427997	.0713998
24	.0416666	.0520000	.0936666	.1873332	.1308997	.0654498
26	.0384615	.0481539	.0866154	.1732308	.1208305	.0604152
28	.0357143	.0448571	.0805714	.1611428	.1121997	.0560999
30	.0333333	.0420000	.0753333	.1506666	.1047198	.0523599
32	.0312500	.0395000	.0707500	.1415000	.0981748	.0490874
34	.0294118	.0372941	.0667059	.1334118	.0923998	.0461999
36	.0277778	.0353333	.0631111	.1262222	.0872665	.0436332
38	.0263158	.0335789	.0598947	.1197894	.0826735	.0413367
40	.0250000	.0320000	.0570000	.1140000	.0785398	.0392699
44	.0227273	.0292727	.0520000	.1040000	.0713998	.0356999
48	.0208333	.0270000	.0478333	.0956666	.0654498	.0327249
50	.0200000	.0260000	.0460000	.0920000	.0628319	.0314159
56	.0178571	.0234286	.0412857	.0825714	.0560999	.0280499
64	.0156250	.0207500	.0363750	.0727500	.0490874	.0245437
72	.0138889	.0186666	.0325555	.0651110	.0436332	.0218166
80	.0125000	.0170000	.0295000	.0590000	.0392699	.0196350
96	.0104166	.0145000	.0249166	.0498332	.0327249	.0163625
100	.0100000	.0140000	.0240000	.0480000	.0314159	.0157080

verse, operating on basic centers.

When this condition occurs, it is necessary either to use a finer pitch to reduce undercutting or to increase the center distance in order to permit the use of standard proportions on the mating gear with enlarged proportions on the pinion. This latter is shown in *Fig. 7*. For approximate calculations, it is sufficient to increase the center distance by one half of Δ_d on the pinion.

If exact center distance is desired, the following formulas may be used:

$$\text{inv}\,\phi_m = \frac{n(t_\delta + T) - \pi d}{d(n+N)} + \text{inv}\,\phi$$

$$C = \frac{(n+N)}{2P}$$

$$C_m = \frac{C\cos\phi}{\cos\phi_m}$$

where ϕ_m = pressure angle at pitch point; t = basic circular tooth thickness (pinion); T = basic circular tooth thickness (gear); C = basic center distance; and C_m = actual meshing center distance.

Sometimes a design has been established using standard proportions on both members, but the number of teeth on the pinion has been found too small for satisfactory operation, after the gear cases have been machined and the mating gears made up. In such cases it has been found that a compromise design on the pinion can often be effected without interfering with interchangeability if a slight reduction in output speed is not too serious. The pinion may be cut with one less tooth on the same diameter of blank. This is termed a modification of one addendum. Amount of diameter increase is $\Delta_d = 1/P$. Outside diameter is

$$d_o = \frac{n+2}{P} + \Delta_d = \frac{n+3}{P}$$

(Note that n is now one tooth less than in the original design). Root diameter is $d_r = d_o - 2h_t$. Approximate center distance check would give

$$C = \frac{n+N}{2P} + \frac{\Delta_d}{2}$$

and will correspond to original center distance. Change in circular tooth thickness of pinion at pitch diameter is $\Delta_t = \Delta_d \tan\phi$ and tooth thickness becomes $t_\delta = t + \Delta_t$. Note that pitch diameter of pinion has decreased since its value is still obtained from $d = n/P$. Actual center distance will be a few tenths of a thousandth less than the approximate formula gives (previous formula for C_m will still apply). Mating gear remains unchanged.

If this method results in too low an output speed, it is quite often possible for the electrical designer to compensate, at least partially, when designing the windings in the motor armature. While this procedure is not as desirable as that outlined previously, it has been instrumental in vast improvement in a number of existing designs without changing anything but the motor armature.

Fig. 3—Proportions of teeth on a 20-tooth pinion and an 80-tooth gear. There is no interference with these proportions, the total line of action is effective, and contact ratio is 1.691

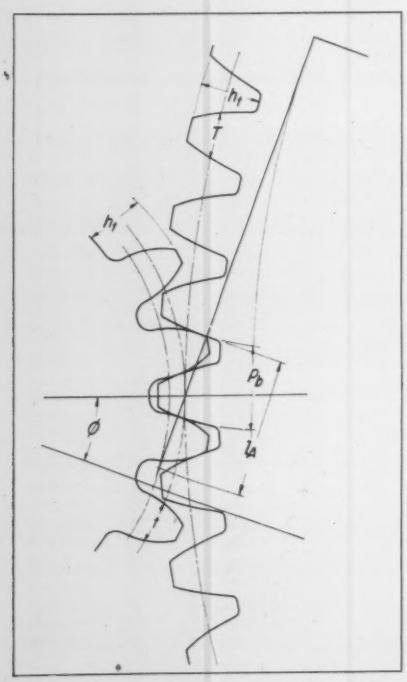


Fig. 4 — Eight-tooth pinion cut to standard proportions, meshing with an 80-tooth gear. Interference weakens pinion teeth and reduces effectiveness of line of action. Contact ratio is only 0.669

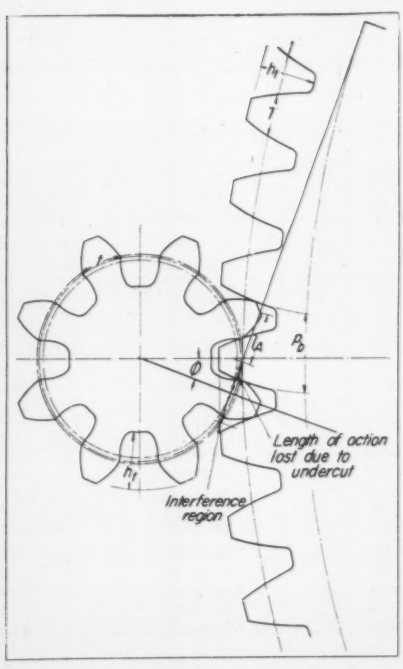
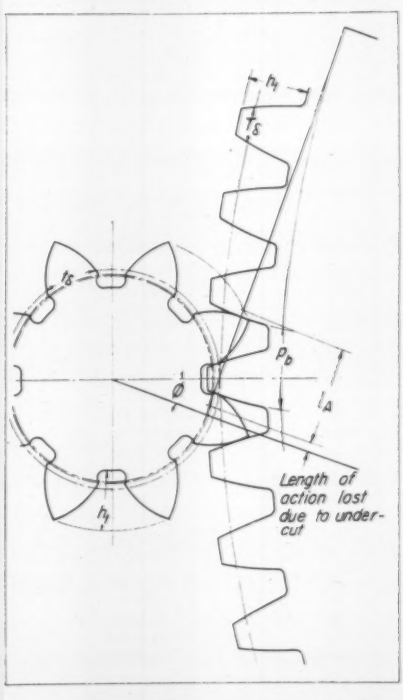


Fig. 5—By enlarging the pinion and decreasing the gear diameter, the 8-tooth pinion and 80-tooth gear combination have an effective line of action (contact ratio 1.238)



Diametral pitches used in this work usually range from 72 to 20 inclusive. Those which are usually encountered are 72, 64, 48, 40, 36, 32, 30, 24 and 20. In the selection of proper pitch for this work, a strange paradox exists. Horsepower capacity as calculated by the conventional Lewis formula may for most applications be doubled with impunity. Hence very fine pitches might be selected and, the finer the pitch the greater the number of teeth for a given center distance and ratio. The greater the number of teeth, the greater the wear load capacity, yet these very fine pitches, when assembled with the variations experienced due to mounting style, etc., will be found unsatisfactory. For this reason, most portable tools use diametral pitches much coarser than necessary for the loads involved and few cases of failure are experienced. Therefore, load calculations usually are of little significance. However, in a few cases very high loads have been taken from this same basic type of equipment and load calculations were found very essential.

Backlash is a matter which needs clarification and which either is not understood or is passed over too lightly. Because of the difficulty in obtaining information from users of motors on the variations which may exist in the gear case and the mating gear, it has been considered necessary to provide rather generous backlash allowance on pinions cut on motor shafts to insure their operation without binding. This does not permit the user of this equipment the service and load capacity that he might obtain if all factors were evaluated and proper distribution of backlash allowance effected.

Backlash Defined

Backlash may best be defined as the looseness in mesh between gear teeth which results from the necessity for recognizing manufacturing variations in the component parts and allowing for contraction or expansion with temperature changes. If all parts could be made perfect and no temperature changes occurred, there would be no need for backlash.

Several elements, together, result in backlash. The AGMA, in their fine pitch inspection standard, have established a method for evaluating the variations on gear teeth; it consists of engaging the part in tight mesh with a master gear and uses an indicator or charting mechanism coupled to the centers, so that change in center distance indicates variation in tooth form, pressure angle, spacing, etc., in one composite reading. The maximum center distance change during the engagement with one tooth is called the "tooth-to-tooth composite error". The maximum center distance change during one revolution of the part is known as the "total composite error". The difference between these readings is considered as the eccentricity, total gage.

In *Fig.* 8 the author has attempted to diagram the entire group of variables which result in backlash, with the exception of temperature effect. It is assumed here that the maximum permissible variation occurs at each interval since this is the condition that must be considered in the evaluation. For purposes of illustration a sixteen-tooth pinion is shown in engagement with a thirty-two tooth gear. Values assigned to each component are not necessarily those which will be found in practice.

e_t = Composite error, tooth to tooth, pinion; tolerance = 0.0008-inch. Size of pinion must be reduced 0.0004-inch radially or 0.0008-inch on diameter to permit operation without binding. As a rule, pinions with small numbers of teeth require greater tolerance than the mating gear because they are difficult to support while cutting and are sensitive to errors in the cutting tool.

e_c = Eccentricity, total gage, pinion; tolerance = 0.0010-inch. Size of pinion must be reduced 0.0005-inch radially or 0.0010-inch on diameter in addition.

V_m = Variation in diameter permitted in manufacture, pinion; tolerance = 0.0010-inch. A variation in size must be permitted the operator of the machine when cutting to depth. Minimum size will cause radial looseness in mesh of 0.0005-inch.

V_d = Total reduction in diameter to allow for backlash, pinion. V_d (min.) = $e_c + e_t$ = 0.0018-inch, V_d (max) = $e_c + e_t + V_m$ = 0.0028-inch. When mounted on a variable center dis-

TABLE II

Amount of Undercut Above Base Diameter for AGMA Modified Tooth Forms (with no fillet on tip of hob)

Diametral Pitch	Number of Teeth												
	6	7	8	9	10	11	12	13	14	15	16	17	18
1	.03158	.02707	.02368	.02105	.01895	.01723	.01579	.01458	.01353	.01263	.01184	.01115	.01053
16	.00197	.00169	.00148	.00132	.00118	.00108	.00099	.00091	.00085	.00079	.00074	.00070	.00066
18	.00205	.00175	.00153	.00136	.00123	.00112	.00102	.00094	.00088	.00082	.00077	.00072	.00068
20	.00146	.00125	.00109	.00097	.00087	.00079	.00073	.00067	.00062	.00058	.00055	.00051	.00049
24	.00129	.00111	.00097	.00086	.00078	.00071	.00065	.00060	.00056	.00052	.00049	.00046	.00043
28	.00118	.00101	.00089	.00079	.00071	.00065	.00059	.00055	.00051	.00047	.00044	.00042	.00039
30	.00114	.00098	.00085	.00076	.00068	.00062	.00057	.00053	.00049	.00046	.00043	.00040	.00038
32	.00110	.00094	.00083	.00073	.00066	.00060	.00055	.00051	.00047	.00044	.00041	.00039	.00037
36	.00104	.00089	.00078	.00069	.00062	.00057	.00052	.00048	.00045	.00042	.00039	.00037	.00035
40	.00099	.00085	.00074	.00066	.00059	.00054	.00050	.00046	.00042	.00040	.00037	.00035	.00033
48	.00092	.00079	.00069	.00061	.00055	.00050	.00046	.00043	.00040	.00037	.00035	.00033	.00031
64	.00085	.00073	.00064	.00057	.00051	.00046	.00043	.00039	.00037	.00034	.00032	.00030	.00029
72	.00083	.00071	.00062	.00055	.00050	.00045	.00042	.00038	.00036	.00033	.00031	.00029	.00028
96	.00081	.00069	.00061	.00054	.00049	.00044	.00040	.00037	.00035	.00032	.00030	.00028	.00027

TABLE III—**Spur Gear Tooth Proportions for One Diametral Pitch***
(Dimensions in inches. For other pitches, divide by diametral pitch)

Number of Teeth	Diameter Increase	Outside Diameter	Pointed Tooth Diameter	Circular Tooth Increase	Circular Tooth Thickness	Chordal Tooth Thickness	Base Diameter	Undercut Diameter	Pitch Diameter
6	1.29813332	9.29813332	9.03632343	.47248188	2.04327821	2.00401284	5.63815572	5.29813332	6.00000000
7	1.18115554	10.18115554	10.07469327	.42990545	2.00070178	1.93757328	6.57784834	6.18115554	7.00000000
8	1.06417776	11.06417776	11.10075877	.38732902	1.95812535	1.93863192	7.51754096	7.06417776	8.00000000
9	.94719998	11.94719998	12.11650686	.34475259	1.91554892	1.90111914	8.45723358	7.94719998	9.00000000
10	.83022220	12.83022220	13.12341816	.30217617	1.87297250	1.86203230	9.39692620	8.83022220	10.00000000
11	.71324442	13.71324442	14.12263307	.25959974	1.83039607	1.82196980	10.33661882	9.71324442	11.00000000
12	.59626664	14.59626664	15.11504717	.21702331	1.78781964	1.78121304	11.27631144	10.59626664	12.00000000
13	.47928886	15.47928886	16.10138372	.17444688	1.74524321	1.74000554	12.21600406	11.47928886	13.00000000
14	.36231108	16.36231108	17.08223092	.13187045	1.70266678	1.69847244	13.15569668	12.36231108	14.00000000
15	.24533330	17.24533330	18.05807840	.08929402	1.66009035	1.65670350	14.09538930	13.24533330	15.00000000
16	.12835552	18.12835552	19.02333808	.04671769	1.61751392	1.61476016	15.03508192	14.12835552	16.00000000
17	.01137774	19.01137774	19.99635909	.00414116	1.57493749	1.57268547	15.97477454	15.01137774	17.00000000
18	.....	20.00000000	21.02043444	.....	1.57079633	1.56880332	16.91446716	16.89439996	18.00000000

* 20-degree involute tooth forms, gears enlarged in accordance with AGMA recommendations.

tance fixture with a perfect master, readings may vary from zero to 0.0023-inch ($e_e + e_t + V_m/2$) throughout the lot, although any given part may not vary more than 0.0018-inch. This may be at any position between zero and 0.0023-inch. This allowance is the only amount to be applied to the size of the pinion.

e_m = Eccentricity of mounting, total gage, motor; tolerance = 0.003-inch. Size of mating gear must be reduced 0.0015-inch radially or 0.003-inch on diameter to allow for this. The mounting for the pinion usually consists of a ball bearing supported in a housing which also carries a pilot for alignment with mating casting. The varying relationship of these causes the necessity for this allowance.

e_w = Resultant variation of gear mesh due to center line of shaft not being exactly at 90 degrees with the mounting face, motor; tolerance = 0.001-inch. Size of mating gear must be reduced 0.0005-inch radially or 0.0010-inch on diameter to allow for this. This does not affect the truth of the pinion but will change the center distance.

C_M = Variation in mean center distance, gear housing; tolerance = 0.002-inch. No reduction in gear size is required if this is maintained in a plus direction.

E_w = Resultant variation at gear mesh due to center line of shaft not being square with mounting face, gear housing; tolerance = 0.001-inch. Size of mating gear must be reduced 0.0005-inch radially or 0.0010-inch on diameter to allow for this.

E_m = Eccentricity of mounting, total gage, gear housing; tolerance = 0.003-inch. Size of mating gear must be reduced 0.0015-inch radially or 0.003-inch on diameter to allow for this.

V_M = Variation in diameter permitted in manufacturing gear; tolerance = 0.001-inch. A variation in size must be permitted the operator of the machine when cutting to depth. Minimum size will cause radial looseness in mesh of 0.0005-inch.

E_t = Composite error, tooth to tooth, mating gear; tolerance = 0.0005-inch. Size of mating gear must be reduced 0.00025-inch radially or 0.0005-inch on diameter to allow for this.

E_e = Eccentricity, total gage, mating gear; tolerance = 0.0010-inch. Size of mating gear must be reduced 0.0005-inch radially or 0.0010-inch on diameter to allow for this.

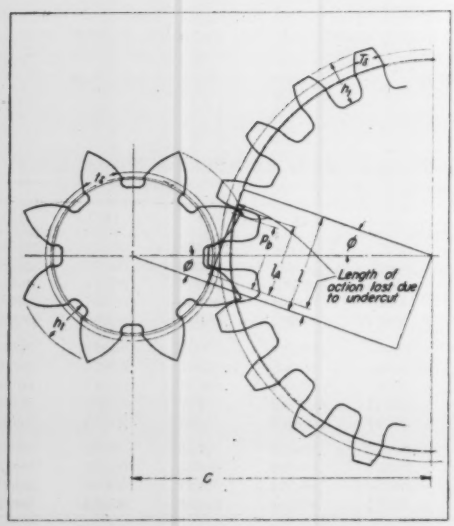


Fig. 6—Left—Eight-tooth pinion and 20-tooth gear, showing undercutting of both sets of teeth. Contact ratio is found to be 1.140

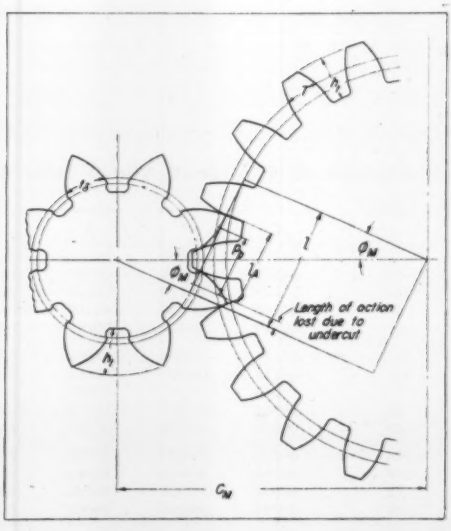


Fig. 7—Right—Modification to Fig. 6, consisting of enlarging the gear and operating at increased center distance. Contact ratio is 1.238

V_D = Total reduction to allow for backlash, mating gear; V_D (min) = $E_e + E_t + E_m + E_w + e_w + e_m$ = 0.0095-inch. V_D (max) = $E_e + E_t + V_M + E_m + E_w + e_w + e_m$ = 0.0105-inch. When mounted on a variable center distance fixture with a perfect master, centers will close at least 0.004-inch ($e_m/2 + e_w/2 + E_w/2 + E_m/2$) and not more than 0.006-inch (above plus $E_e + E_t + V_M/2$) throughout the lot, although any given part may not vary more than 0.0015-inch. This may be at any position between 0.004-inch and 0.006-inch.

B_H = Tangential backlash on operating centers, total. B_H (min) will be zero if all permissible variations occur in one extreme at the same instant on one set of parts. B_H (max) = $(e_t + e_e + V_m/2 + e_m + e_w + C_M + E_w + E_m + V_M/2 + E_e + E_t) \times \tan\phi$ = 0.0143 × 0.36397 = 0.0052-inch. However, it is seldom that these extremes occur at the same time. A normal frequency distribution will result in 99.73 per cent assembly if the laws of probability are used. Thus, the actual variation in most instances will be as follows:

$$B_H(\max) = \sqrt{(e_e+E_e)^2+e_t^2+\left(\frac{V_m}{2}\right)^2+e_m^2+e_w^2+C_M^2+E_w^2+E_m^2+\left(\frac{V_M}{2}\right)^2+E_t^2}\times\tan\phi$$

$$= 0.00542 \times 0.36397 = 0.0020\text{-inch}$$

A great many manufacturers use "topping" hobs to produce their gears. These have the effect of reducing the outside diameter and root when the hob is impressed more deeply into the blank to obtain the results outlined above. This has a detrimental effect on contact ratio. To overcome this, two methods have been used, a thick-tooth hob which will thin the teeth a predetermined amount when cutting to full diameter and a nontopping hob which will cut the sides and root without touching the outside diameter until it has been impressed a radial amount equal to the clearance. Clearance has been established for fine pitch gears (20 diametral pitch and finer) as 0.2 divided by the diametral pitch, with 0.002-inch added to the result. On gears coarser than 20 pitch, the value can be obtained if 0.157 is divided by the pitch. When gears are cut by the Fellows shaping method, the cutters are usually of the nontopping type and may also be obtained with thick teeth if desired.

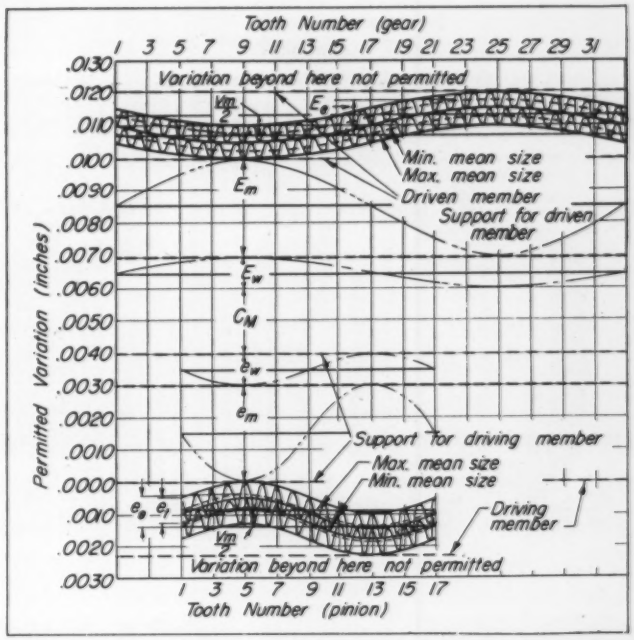


Fig. 8—Diagram showing the elements of radial backlash

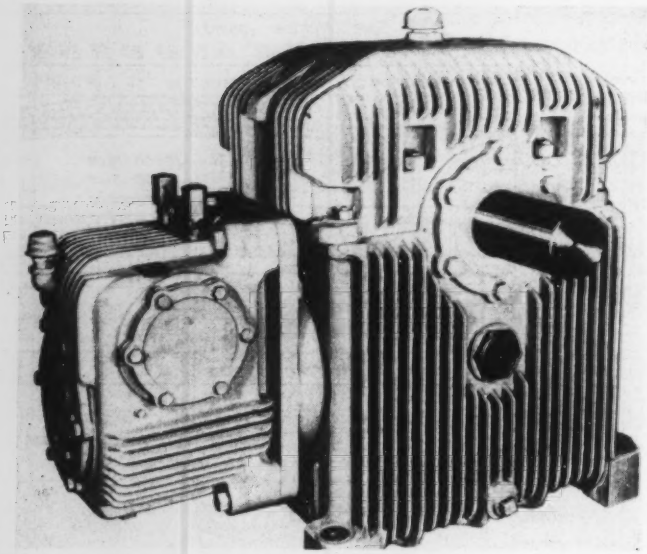
Since most of these pinions with small numbers of teeth are cut on the motor shaft by hobbing methods, the problem of hob "runout" or the arc between the full depth cut and the outside diameter of shaft which is produced by the radius of the hob is one which must be considered. With a large diameter hob, a substantial supporting arbor can be used with a "shell type" hob and a large number of "gashes" or teeth can be obtained. Thus good finish and accuracy result. However, the runout section is long and the pinion is unsupported except for the adjacent motor bearing.

It has been our practice to maintain two series of hob diameters with relation to diametral pitch, the larger for accuracy where space is not a problem and the smaller for reduced runout section with some possible penalty on accuracy.

TABLE III summarizes the proportions of the pinions which have been discussed in this article.

Multiple Reductions from Standard Units

BY using standard speed reducers as primaries and secondaries, a new line of double-reduction units comprising over 86,000 combinations as to capacity, model and ratio has been made available by the Cone-Drive Division of Michigan Tool Company. The combination of standard reducers, *Fig.* 1, provides models with input ratings of from ½ to 68 hp, from 4000 to 244,000 in-lb output torque, and reduction



ratios ranging from 25-to-1 to as high as 4900-to-1.

Standard ratios for primary and secondary reducers can be combined in a number of ways according to operating requirements to give the same overall ratio, as shown in the table. Similarly, size of the primary or secondary reducer can be varied to suit the specific operating conditions.

Individual primary and secondary reducers are interchangeable and separately replaceable within given size ranges and may be dismounted and quickly converted to single-reduction units if desired, since each component retains its independent lubricant supply and breather. Use of standard gear sets also makes it simple to change the ratio of any combination where and if desired since all gear sets and bearing mountings are interchangeable for all models of the same size. This feature facilitates maintenance replacement.

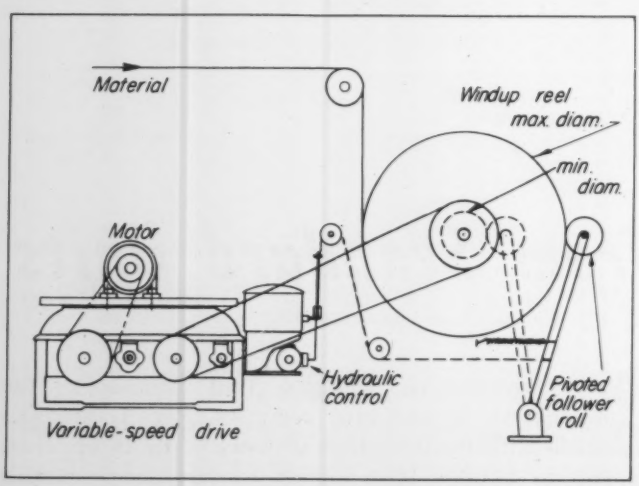
Overall Ratios Obtainable by Combining Speed Reducers

Primary \ Secondary	5	10	15	20	25	30	40	50	60	70
5	25	50	75	100	125	150	200	250	300	350
10	50	100	150	200	250	300	400	500	600	700
15	75	150	225	300	375	450	600	750	900	1050
20	100	200	300	400	500	600	800	1000	1200	1400
25	125	250	375	500	625	750	1000	1250	1500	1750
30	150	300	450	600	750	900	1200	1500	1800	2100
40	200	400	600	800	1000	1200	1600	2000	2400	2800
50	250	500	750	1000	1250	1500	2000	2500	3000	3500
60	300	600	900	1200	1500	1800	2400	3000	3600	4200
70	350	700	1050	1400	1750	2100	2800	3500	4200	4900

Although the line provides some 86,000 possible combinations, there are actually only five sizes of primary reducers and eight sizes of secondaries. Two of the primaries (2½ and 3-inch center distance) can be combined with four of the secondaries (4 to 7-inch center distance). The three other primaries (4, 5, and 6-inch center distance) go with the other four secondaries (7 to 12-inch center distance). These center distances correspond to much larger sizes in conventional reducers due to the greater load carrying capacity of the double-enveloping gearing used.

Automatic Windup Control

In order to maintain uniform tension on machines which wind or unwind material it is very necessary to operate the winding attachment at a uniform speed at all times. Since linear speed of the material increases as the diameter of the takeup roll increases, it is necessary to provide an automatic control to compensate for this change in roll size. One system for doing this is the combination of a follower roll indicating device and a Reeves variable-speed transmission. This system is applicable to many machines wherein varying conditions require control.



The accompanying diagram shows such a control applied to a windup reel. A pivoted follower roll rests against the reel motion of the follower actuating a hydraulic control which regulates the transmission. At the beginning of a run, the follower roll is resting on the core of the windup reel. As the material builds up, the follower roll is pushed back; the movement is transmitted to the hydraulic control which automatically shifts the transmission, and likewise the reel, to a slower speed. This movement of the follower roll and the consequent decrease in speed continues throughout the winding, compensating for the increasing diameter. Speed of the material being wound is uniform, therefore, regardless of the diameter of the reel.

Control Instruments

Basic types and their selection

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NOW, more than ever before, a thorough appreciation of the effectiveness of the various types of basic automatic control systems is of paramount importance to industrial equipment and machine designers. With the advent of practical means for evaluating product qualities such as gloss, reflectance, pH, conductivity, moisture content, color, and a host of others hitherto subject to cumbersome sampling test laboratory types of control, many new control applications are finding their way into modern industry. For example, the development of a means to measure electrically the moisture content of a cotton warp as it passes through the slasher made possible the automatic control of the slasher speed. This system

shown in *Fig.* 1, greatly increased operating efficiency for textile mills.

CHOICE OF CONTROL: Regardless of the nature of the primary sensing (i.e., measuring) device or the process variable (such as temperature or moisture) under control, the choice of control system remains dependent upon certain process characteristics whether the process is batch, semicontinuous or continuous. Such characteristics as the capacity, process time lag, and the rate at which the process comes to equilibrium when a change is permitted for the process variable, determine the type of control needed. In general, these characteristics affect the selection of a control system as discussed in the following paragraphs. (Note: In the definitions, temperature is cited as the variable.)

Capacity: Capacity in the form of either fluid volume or heat content is of two types, demand-side capacity and supply-side capacity. Both types of capacity tend to produce lags, but relatively large demand-side capacities tend to keep the system in equilibrium. For example, when heating a large tank of liquid with equal input and output flows, the large mass of liquid in the tank constitutes a storage capacity which tends to resist temperature changes resulting from uneven firing, changes in the rate of flow, and other factors. Therefore, the corrective action of the control element need not be extremely complex.

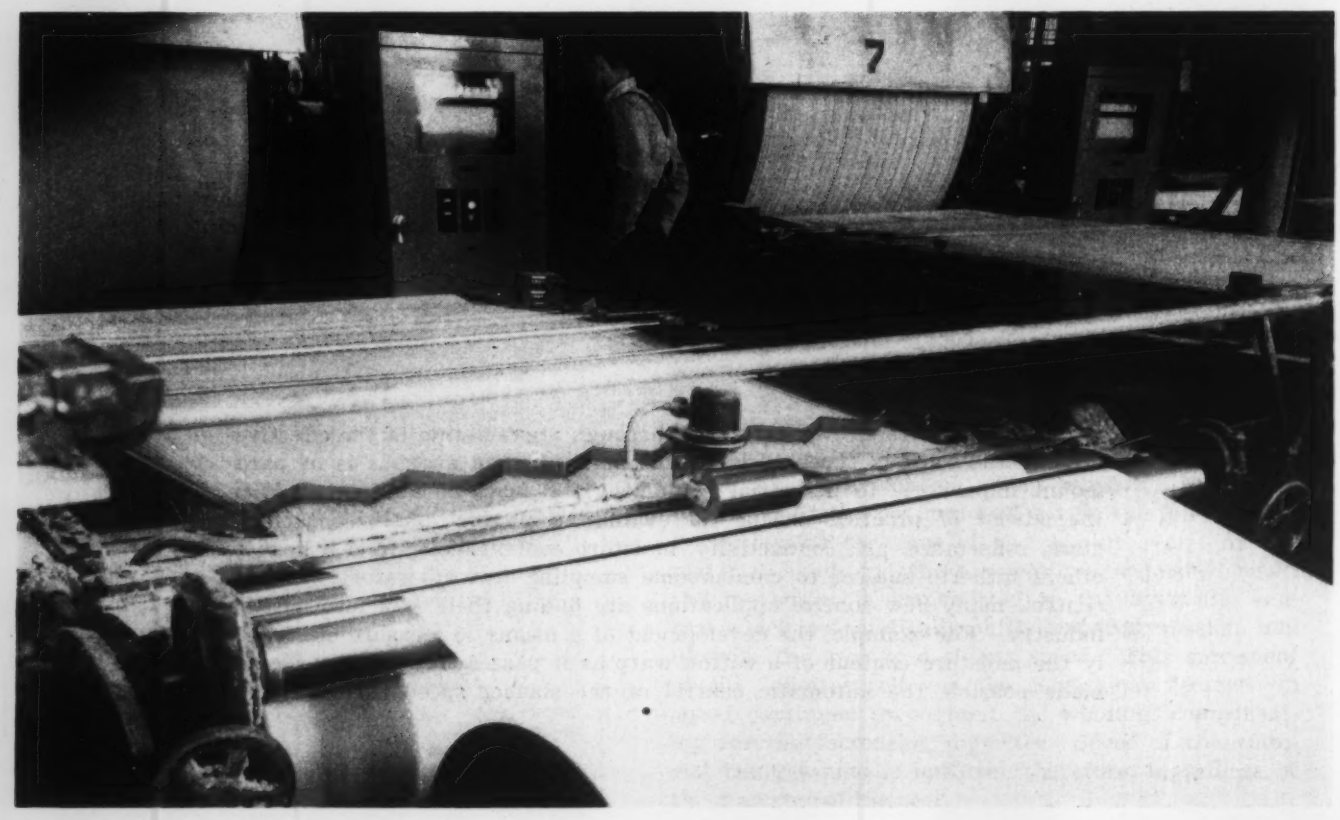
If, however, a high-velocity heat exchanger is considered in place of the larger tank, the relatively small quantity of liquid in the exchanger at any one time constitutes a relatively small storage capacity. Hence, slight variation in firing, rate of flow, etc., are reflected immediately in the product temperature. As a result, a highly sensitive control system with a corrective action precisely attuned to the process is essential.

Time Lag or Dead Time: Process time lag is the elapsed time interval from the occurrence of a process change and the instant its effect is felt by the measuring element. In general, the shorter the time lag, the more simple the form of control employed. However, final determination of the form of control must be derived from a consideration of all the process characteristics. Insofar as the time lag itself is concerned, the following are the determining factors:

1. Thermal conductivity of the material being heated
2. Amount of heating surface in relation to the mass of material being heated
3. Temperature differential (i.e., between the heating agent and the material being heated)
4. Thermal conductivity of the materials forming heating and containing surfaces, as well as of fluid films on these surfaces.

Equilibrium Rate: The rate at which a process comes to equilibrium when a new rate of heating is applied is highly important especially in those cases

Fig. 1—Moist-o-Graph control measures the moisture content of cotton warp as it passes through the slasher by measuring the passage of electric current through the warp on the delivery end of the slasher



where there is appreciable process lag. This rate is determined by several factors, namely, mass or capacity of the system, thermal potentials, conductivity of the materials used in the equipment, and process lag. In general, the rate of equilibrium is independent of load changes. Thus, the equilibrium rate constitutes a highly important factor governing the rate at which the control valves (or other control elements) are opened and closed.

If the following factors are carefully considered when a control problem is to be analyzed, the correct control instrumentation is practically assured:

1. Magnitude of load changes. Affects the size of the control valve or controlling mechanism
2. Rates of load change. Determine the degree of complexity of the control problem and, therefore, the type or mode of control best adapted for the case at hand
3. Rates of heat absorption (i.e., rates of stabilization or equilibrium)—Determine the controller adjustments (proportional band and automatic reset) and are, therefore, the factors governing the synchronization of the controller with the process at hand.

TYPES OR MODES OF CONTROL: There are four basic modes of control systems, all but one of which can be obtained in either electric or pneumatic forms. Selection of the electric or pneumatic form of control equipment largely depends on the exigencies of each particular application. In general, it depends upon whether an air supply is available, whether explosive or inflammable conditions preclude the hazard of electric operation, and, in some cases, upon the nature of the final control element. For example, it is most practical to control the operation of electric switches and relays electrically. The choice of the proper basic mode of control regardless of whether the electric or pneumatic form is employed, rests with the process characteristics.

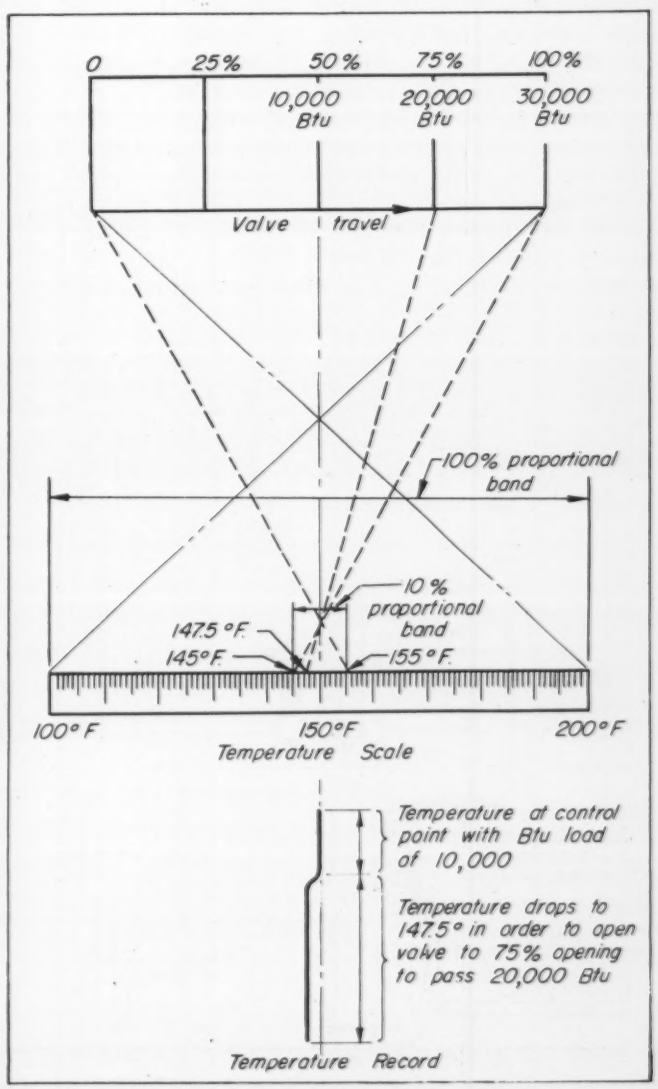
Two-Position Control: As the name implies, two-position control is that type in which high and low contacts (or pneumatic equivalent) on either side of an adjustable set point (i.e., point at which control is desired) are used to actuate the final control element. One contact can be used to produce a full or partial increase, and the other to produce a full or partial decrease of the material under control. This control action is not cognizant of either rate or magnitude of load changes. Consequently, it is not satisfactory in applications which have unfavorable process characteristics such as rapid variations in rate of load changes. It is generally suited to systems with large storage capacity, minimum process lags, and low thermal potential.

Proportional: In the proportional type of control, (sometimes called throttling control), the valve or other final control element assumes positions dictated by the position of the recording pen with respect to the control index. In this way, there is a definite position of the control element for every scale value within certain limits. The amount of control element movement with respect to a specific change in the measured variable is proportioned by means of a proportional band adjustment on the controller. The width of this adjustment is defined in terms of percentage of full scale movement of the pen and is shown graphically in *Fig. 2*.

The proportional type of control recognizes rate, magnitude, and direction of changes in the controlled variable and provides a continuous linear corrective action. The greater the percentage of unfavorable control factors such as, limited storage capacity, long process lags, high thermal potentials, and oversize control valve, generally, the greater the width of proportional band adjustment that is necessary. However, the greater the width of this adjustment, the greater the droop or permanent departure from the set point for any given load change. To overcome this effect, automatic reset action is provided with some proportional controllers.

The purpose of automatic reset is to return the pen to the set point after a load change. In this

Fig. 2—Graphic analysis of proportional band control



way the effects of droop are eliminated. Automatic reset is activated immediately the pen deviates from the set point. Its action and the throttling action occur simultaneously. Proportional control with automatic reset is used when a demand for precise control under adverse conditons must be met.

Floating Control: The most common type of this control which is not combined with another mode is known as single-speed floating control and is usually found only in electrically operated systems. A two-position controller having a neutral zone between high and low contacts causes a reversible motor to move gradually at a constant rate toward one or the other extreme of travel, depending upon whether the controlled variable is above or below the neutral zone. While the variable is within the neutral zone, the motor "floats" in the last position attained at the time the variable entered the zone. From a control standpoint, the system does not recognize rate, magnitude, nor direction of change within the neutral zone. Hence, it is applicable only to control problems involving large capacities and limited time lags and to those where electric control is essential.

Rate Action: Rate action provides an initially large corrective action when the variable deviates from the set point, so that the final control element is at first moved further than would normally occur with proportional or proportional with reset action. The effect is an early extra change which tends to counteract the unfavorable effect of a process lag.

Applications for each of the preceding modes of control may be summarized in general as shown in TABLE I. These various control systems find use in all industries wherever the need for control exists.

TABLE I—**Control Applications Characteristics**

Mode of Control	Process Capacitance	Transfer Lag or Dead Time	Process Load Changes
Two-Position	Large	Slight	Small & Slow
Proportional	Large or Med.	Small or Moderate	Small
Proportional—Reset	*	Small or Moderate	Slow
Proportional Plus Rate Action	Small or Med.	*	Small
Proportional—Reset Plus Rate Action	*	*	*

* In general any amount

In general, they are adaptable to the control of any variable. Regarding the instruments used with each type of control system, TABLE II lists the standard types of industrial instruments, the variables they measure, and the types of control available with them.

TYPICAL CONTROL APPLICATIONS: Inasmuch as the instruments and control forms listed in the foregoing find application in virtually all phases of industry, the following examples illustrate control systems which may be readily adapted to the particular needs of any industrial application. In addition, it should be remembered the control form, together with the final control element, are interchangeable with respect to the primary measuring device. For example, the speed-control system described in the following can be readily utilized for proportionally controlling various forms of continuous drying devices at the command of a primary measuring element sensitive to color, temperature, humidity, and the like.

Cotton Slasher (Textile application—floating con-

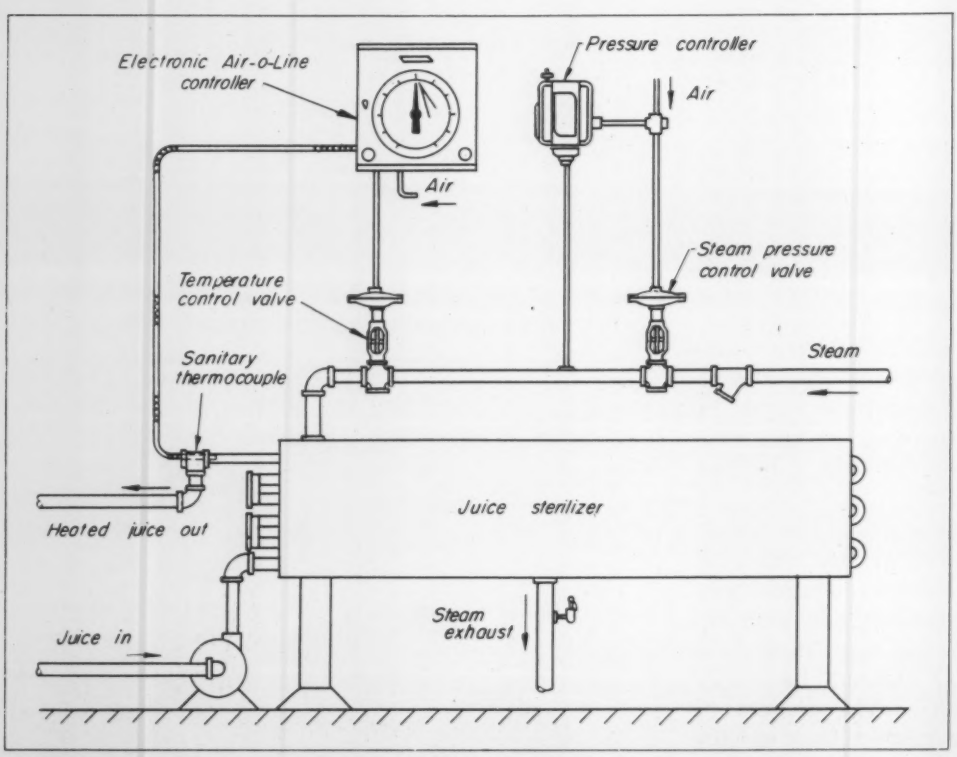


Fig. 3—Control arrangement for a high-speed continuous pasteurizer

trol of speed): In the textile industry, properly sized warps containing the correct moisture content, are highly important to efficient operation. By controlling the speed of the slasher, a properly dried warp with the optimum moisture content results. This is automatically accomplished with the control system shown in *Fig.* 1.

As shown, a detector roll contacts the warp yarn as it passes over the back press roll on the delivery end of the slasher. The amount of current which passes from the detector roll through the yarn to the back press roll is directly related to the moisture content of the warp and is accurately measured by the Moist-o-Graph. The measuring instrument is

TABLE II—Standard Control Instruments

Type of Instrument	Measured Variable	Type of Control
Millivoltmeter Indicators	Millivoltage & Temperature	Electric only—2 position
Flow & Liquid Level Meters and Recorders	Flow & Liquid Level	Pneumatic—2 position proportional, proportional with reset Electric — Two - Position sometimes used with mechanical flow recorders
Recording Thermometers and Pressure Gages	Temperature & Pressure Liquid Level	Pneumatic — Two-Position, proportional, proportional with reset Electric—Two-Position only
Electronic Potentiometer Type Recorders	Pyrometric temperatures, Temperature measurements via resistance thermometers, speed, pH (hydrogen ion concentration), conductivity, pressure, weight, force, appearance qualities, chemical composition and many others	Pneumatic — Two-Position proportional, proportional with reset Electric — Two - Position proportional, proportional with reset

equipped with two indexes, set to the upper and lower limits of the desired range of yarn moisture content. When the upper index is exceeded, a contact is made which energizes a circuit so as to cause the variable-speed drive unit to reduce the speed of the slasher. This reduces the moisture content of the warp, since the temperature of the drying cylinder is maintained at the same level at all times.

Conversely, when the lower index is met, the speed of the slasher is increased. Thus, the effect is to hold the moisture content extremely close to the desired value. By setting the upper and lower indexes relatively close, the moisture content can be held close to an optimum value suitable for all practical purposes.

Flash Pasteurizer (Food industry application—precise regulation of temperature with proportional control and automatic reset): The operation of continuous, high-speed flash pasteurizers necessitates precise control of temperature. As a result of the short time involved in this type of process, high sterilization temperatures are used. (For example, tomato juice is processed for 0.7-minute at 250 F.) If this high temperature is not accurately maintained, product spoilage (as the result of insufficient temperatures for the complete destruction of troublesome bacteria) and "burn on" (resulting from temperatures which are too high) generally occur.

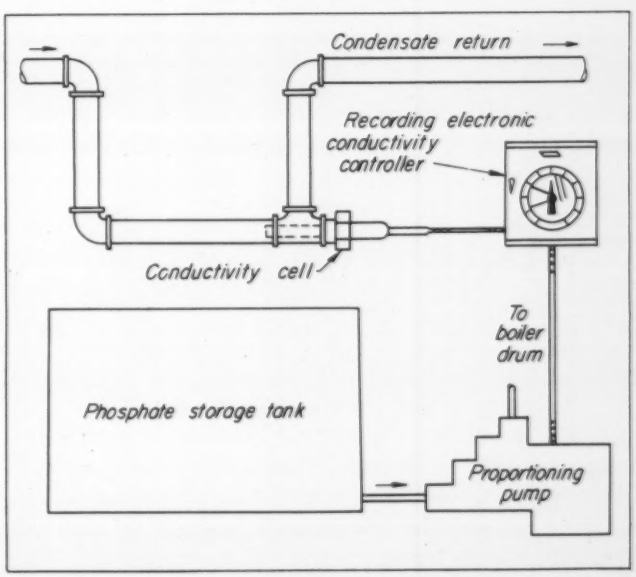
To hold temperatures within plus or minus 1 degree of the desired value, the control system shown in *Fig.* 3 is employed. Because of the small capacity of the system and other factors, proportional control with automatic reset is needed to secure precise control of temperature. As shown in the diagram, steam to the sterilizer is held at a constant pressure by a nonindicating pressure controller. This assures a steady steam supply. The temperature of the juice (or other liquid) is measured by a thermocouple placed in the juice outlet line which is connected to a recording potentiometer. The potentiometer actuates a self-contained Air-o-Line control unit which produces changes in the air pressure supplied to the temperature control valve in accordance with temperature deviations from the set point. These changes result in positioning the diaphragm-operated control valve as necessary to correct for such deviations.

Since proportional control is used, the temperature is held at the desired level with practically no cycling. In addition, the controller automatic reset action eliminates the possibility of "droop" or departure from the desired level. Thus, the juice temperature is maintained and sustained precisely as desired.

Basically, the juice sterilizer is a tubular heat exchanger. Therefore, the control system used with or without some modifications, is applicable to heat exchangers used in the chemical industries and elsewhere.

Boiler Condensate Control (Power plant application—automatic proportional control of softener

Fig. 4—Control arrangement for softener feed to boiler drum



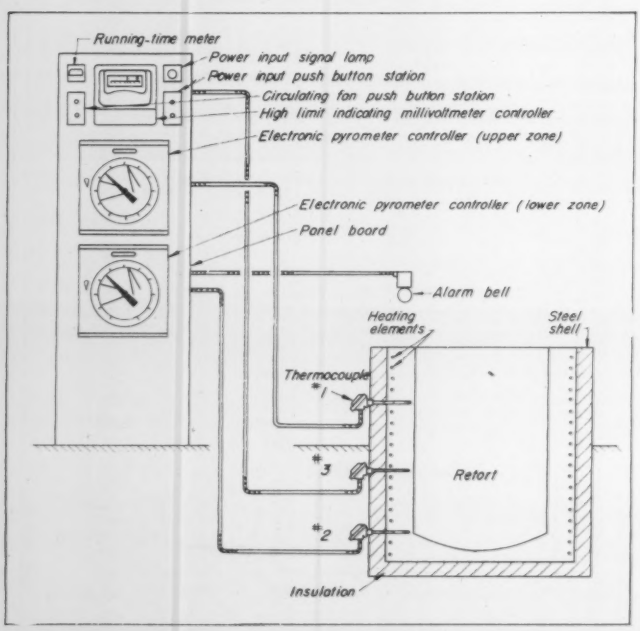
feed): In a closed boiler system, contaminants in the condensate are frequently removed by phosphate softeners. To avoid the precipitation of calcium phosphate in pipe lines, pressure taps, level controllers, and similar equipment, the phosphate softener is often introduced directly into the boiler drum. In such cases, automatic control of the softener feed can be provided by the use of a conductivity recording controller to measure the concentration of contaminants in the condensate return line and regulate the phosphate feed in accordance with this demand.

Since the condensate flow is generally relatively constant, the electric proportional control system, shown in *Fig.* 4, is usually adequate. In this operation, the electrical conductivity of the condensate is measured by means of a conductivity cell and a recording potentiometer controller.

The potentiometer controller utilizes an electrical arrangement to position the stroke mechanism and the proportioning pump. In this way, depending upon the amount and direction of a deviation of the pen from the control point, the pump action is either speeded or retarded. Thus, the volume of softener fed to the boiler is continuously regulated so as to maintain optimum conditions.

A control system analogous to this is found in the treatment of raw water for domestic or municipal use. In this operation, pneumatic control of a dry lime feeder based on pH (hydrogen ion concentration) measurement is employed. Essentially the two systems are the same, one illustrates the controlled proportioning of a dry reagent and the other that of a liquid reagent. However, system requirements in each case may often entail some modifications in the control system.

Fig. 5—Control arrangement for an electrically heated two-zone gas carburizing furnace



Heat Treating Furnace (Metal industry application—on-off temperature control of electrically heated gas carburizing furnace): To obtain uniformly treated metal parts in an electrically heated gas carburizing furnace, close control of temperature is imperative. In batch type furnaces for this purpose, the thermal capacity is generally great enough to permit the use of two-contact, on-off control. However, these furnaces are most always fabricated so as to be divided into two or more heating zones. This is to insure an even distribution of temperature.

The control system for a two-zone carburizing furnace is shown in *Fig.* 5. Each ElectroniK pyrometer controller measures the temperature of a particular zone in the furnace. Thus, if the temperature of either zone deviates from the desired value, the controller turns the power to the associated heating elements on or off as necessary. Since the set point index of each controller is at the same value the combined action keeps the furnace constantly and uniformly at the desired level.

The high limit indicator millivoltmeter controller provides on-off control of the power input to the furnace. The control point index of this instrument is set at some high temperature value as a safety precaution in the event of an uncontrolled temperature rise. The alarm, signals, and pushbutton switches are for operating convenience and safety.

On-Off Control Has Widest Usage

The on-off control system just described probably has a greater number of applications than any other system, particularly in batch operations. Batch operations in general are characterized by large and relatively constant loads. Thus, this type of control is applicable to such equipment as cooking kettles, retorts, drying kilns, vats, salt baths, and ovens.

VARIABLES SUBJECT TO CONTROL: Variables subject to control are constantly being augmented by new and improved sensing devices. Besides the more commonly controlled variables of humidity, temperature, pressure, flow, and liquid level, are many which may become just as common in the not-too-distant future. It is impossible to list or predict all such variables. However, the following seem the most applicable:

Load and Pressure Cells: Recently, load and pressure cells, operating on the strain-gage principle, have become available. These units make possible the continuous electrical measurement of loads up to 50,000 pounds, and pressures up to 50,000 psi.

Since the load cell provides a continuous measurement of load or weight and requires no resetting of counterbalance weights, it furnishes a good medium for controlling the weight of tanks and loads on cranes, and the like. It also supplies a medium for the control of force such as the pull exerted by an engine, winch or other piece of heavy machinery.

Because of the high-pressure range at which this type of pressure cell operates, it provides a possible control medium for use on heavy hydraulic equip-

ment, autoclaves, turbines, engines, and high-pressure steam boilers which was hitherto impossible.

Density Measuring Device: The continuous measurement of density by a novel electrical method has made feasible the control of a flowing process-liquid. Since the new method is electrical in nature, it permits the use of a potentiometer type instrument to continuously control a multitude of mixing, blending, evaporating, concentrating, and make-up operations. In all such operations, the individual process characteristics dictate the choice of the control form. On-off, proportional, or proportional with reset, pneumatic or electric control forms can be employed. The final control action can be used to operate valves, feeder devices, dampers and the like.

Gas Analyzers: In recent years, several different types of gas analysis equipment have become available. These devices are designed for industrial service on flowing process streams and are, therefore, applicable as control elements and have been so used. The following are the major types of gas analyzers which are most successfully used in process control:

1. *Combustible Gas Analyzers:* These analyzers employ a sensitized filament to determine the concentration of any combustible gas within their lower explosive limits. Control applications include, the energizing of alarm circuits, operation of ventilating shutters, dampers, or blowers, and in certain cases the operation of process control elements. As an example of this latter application, their use in coating and vapor recovery systems may be cited. In ovens where a volatile solvent is removed from a coated material, the rate at which the solvent is removed often determines the quality and appearance of the finished product, also the efficiency of the process itself. Here, the gas analyzer is used to maintain the rate of removal by controlling the passage of air through the oven.

2. *Thermal Conductivity Gas Analyzers:* Such analyzers are used to continuously measure the concentration of inert gases such as carbon dioxide, nitrogen, helium, and neon. Their most frequent applications involve the control of the purity of a gas, the proportioning of one gas to another, and controlling the contamination of a gas.

3. *Spectrometer Type Gas Analyzers:* This type of gas analyzer utilizes the selective absorption of ultraviolet or infrared radiation exhibited by many gases. It readily evaluates the concentration of such gases by evaluating the degree of absorption. Since measurement is continuous, it is used as a sensing device for the control of process streams in the drug and petroleum industries where the concentration of such substances as benzene, toluene, cholorphyl, carbon dioxide, and many organic gases, are important factors.

4. *Other Types:* Special gas analyzers are available for the measurement of oxygen concentration. These have control applications in various combustion operations. Other special gas analyzers are made for measuring specific gases. These, however, are used in highly specialized control applications.

General: In general, any variable that can be expressed in minute voltage, resistance, or current changes presents the possibility of control. A host of devices, based on this assumption and whose descriptions would involve too lengthy a discussion, have but lately become available. However, most of these are restricted to specific industries and applications. Suffice it to say that apparatus for the measurement and control of: Appearance factors such as surface gloss, reflectance brightness and color; chemical compositon such as oxidation-reduction potential, salinity, alkanity, and acidity; and color; chemical composition such as oxidation-reduc-

use.

SUMMARY: The preceding discussion of basic control factors and control forms in no way constitutes an exhaustive treatment of the subject of automatic control. No engineering discussion was presented for the solution of any particular control problem as each is usually separate and distinct. An exhaustive treatment covering all control forms, variations, and their method of application is not within the scope of any article. However, it is felt that the information governing the *selection* of the basic kind of control, the *kinds* of control and instrumentation available, and the many variables it is now possible to measure and control, will furnish the design engineer with valuable forethoughts relating to his particular problem.

Automatic Overdrive Fits Chevrolet

AN automatic, all-mechanical overdrive for installation on most Chevrolet cars is now being manufactured and distributed by the Truckstell Manufacturing Co. of Cleveland. It operates in all forward speeds, does not permit "free wheeling" in any speed and provides for a "hill holder" so that the foot brake need not be used after the car has been stopped on a hill. Rear axle and gear box do not require alteration, the overdrive unit being installed in place of a section of the torque tube that is removed.

Shifting is entirely automatic after the mechanism has been set for overdrive operation. Easing up on the accelerator causes the overdrive gearing to be cut in. Full depression of the accelerator pedal or any depression of the clutch pedal causes the unit to automatically fall back into direct drive. Dash-

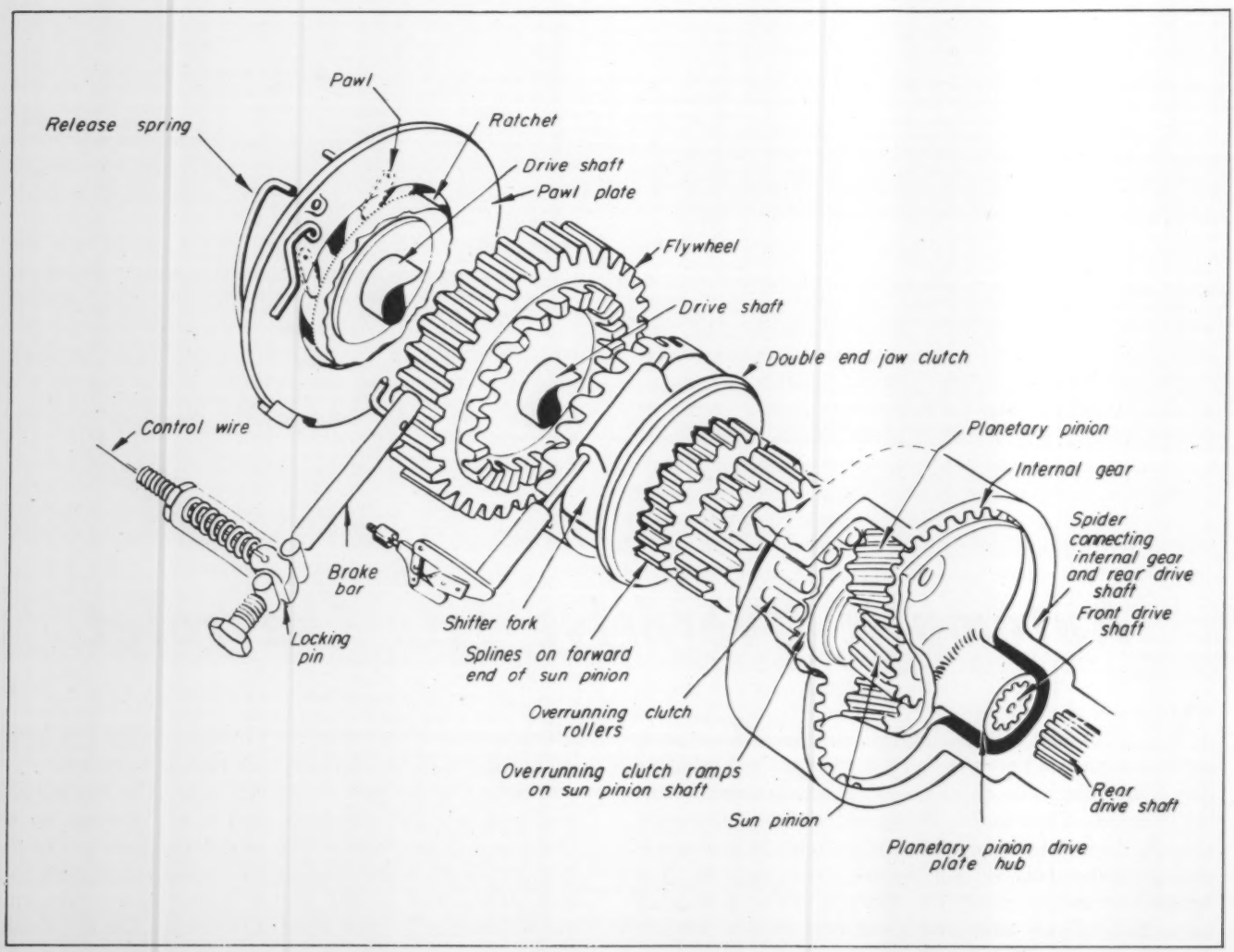
mounted manual controls also permit locking the system in direct drive.

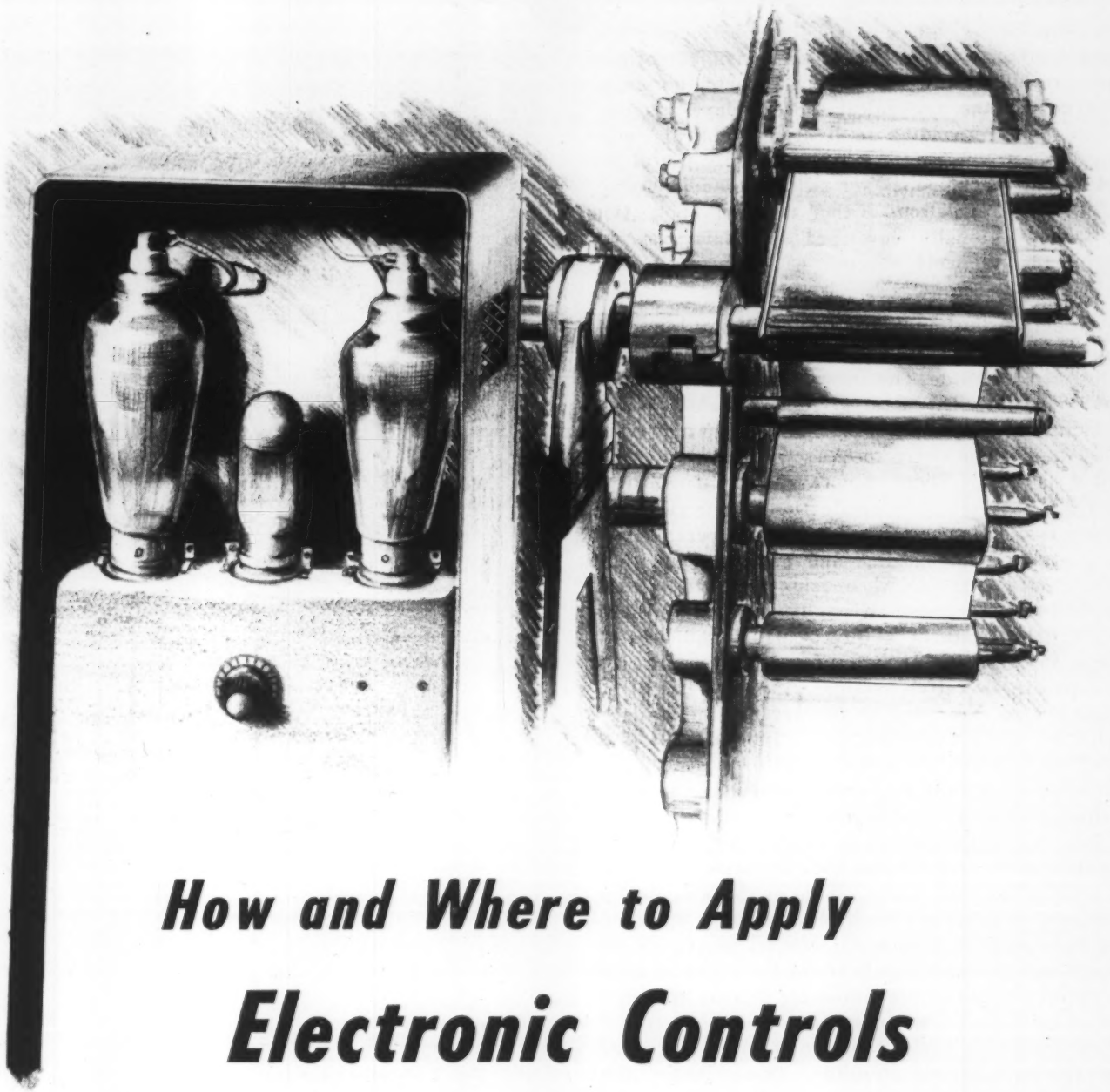
In construction, the overdrive unit consists of a simple three-pinion planetary gear unit that steps up the gear ratio by 28 per cent, a sliding double-ended jaw clutch which engages the overdrive control when in forward position or positively locks out the planetary drive when in the rear-most position, and the overdrive control mechanism at the front end of the unit. It operates as follows: Shifting a control lever on the dash to overdrive position engages the sliding double-ended jaw clutch with a notched flywheel (both clutch and flywheel are free to rotate independently of the forward drive shaft). This jaw clutch slides on a splined extension of the sun-gear hub and connects flywheel and sun gear as one unit. A spider carrying the three planetary gears is splined to the forward drive shaft and rotates at engine speed when in direct and overdrive positions.

When in overdrive operation, the flywheel is held stationary by a brake bar which also prevents rotation of the sun gear. Power is transmitted through the forward drive shaft, spider and planetary gears and then through the internal or ring gear to the rear section of the drive shaft. The planetary gears run around the sun gear when driving the internal gear.

In automatically shifting to direct drive, full depression of the accelerator pedal or partial or full depression of the clutch pedal trips the brake bar holding the flywheel, allowing flywheel and sun gear to rotate. When the sun gear is turning at the same speed as the internal gear, a roller-wedge type overrunning clutch locks flywheel, sun gear and internal gear together, resulting in direct drive through the unit. This clutch between sun and internal gears is one of the unique features of the system. It permits shifting into direct drive noiselessly and without shock because the overrunning clutch between sun and internal gears engages immediately. Conversely, as soon as the internal gear (to which the clutch is attached) starts to increase its speed, which occurs when the flywheel and sun gear are stopped, the clutch releases at zero torque, again without shock to the mechanism.

In direct drive (when set for automatic operation) the power is transmitted from the forward drive shaft through the planetary spider and gears, through the internal gear and to the rear drive shaft. In this case, however, the planetary gears do not run around the sun gear as when in overdrive. Instead, the sun, planetary and internal gears are locked together by the overrunning clutch and rotate as a unit.





How and Where to Apply Electronic Controls

By E. H. Vedder
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Buffalo

IN applying electronic controls the designer should use the proper combination of control elements to give the best balance of first cost, reliability, performance and maintenance expense. This planning cannot be limited to the control only, it must also be extended to the problem from a system point of view. General fields of application where electronic controls are best adapted are now becoming clearly defined. Electronic circuits are especially useful for amplifying small signals, responding to short

signals of too short duration for relays, performing highly repetitive relaying and power switching operations beyond the mechanical life of relays and contactors, and responding to light and optical conditions. Electronic equipment is especially useful for motor control, timing, power switching and relaying, and process regulation. Other fields of application are being gradually developed but have not yet reached the practicable stage.

Speed Adjustment By Varying Motor Input

MOTOR CONTROL: The most widely accepted electronically controlled motor drives use a shunt-wound dc motor as it has both wide speed range and desirable speed-torque characteristics when used with the proper control. These motors can be modified to meet a great variety of applications. The electronic control system for shunt-wound motors operates from an alternating-current line and has many desirable features not available when using magnetic control. The Mototrol electronic adjustable-speed drive shown in *Fig.* 1 consists of a direct-current shunt-wound motor, the field and armature of which are energized by separate thyratron rectifier circuits. These rectifiers are so controlled as to vary the input to the motor for speed adjustment. In this particular system they regulate the motor speed to a preset value and limit the maximum current furnished the motor during acceleration and reversal.

This electronic control permits smooth stepless adjustment of motor speed over a range of at least 20:1 below the base speed of the motor, and over an additional field-control range of as much as 4:1 above the base speed. This speed control is readily obtained over the full range below and above basic speed by means of a small potentiometer located in a push-button station convenient to the operator.

Combined with the wide range of speed control are the speed-regulating circuits. These insure that

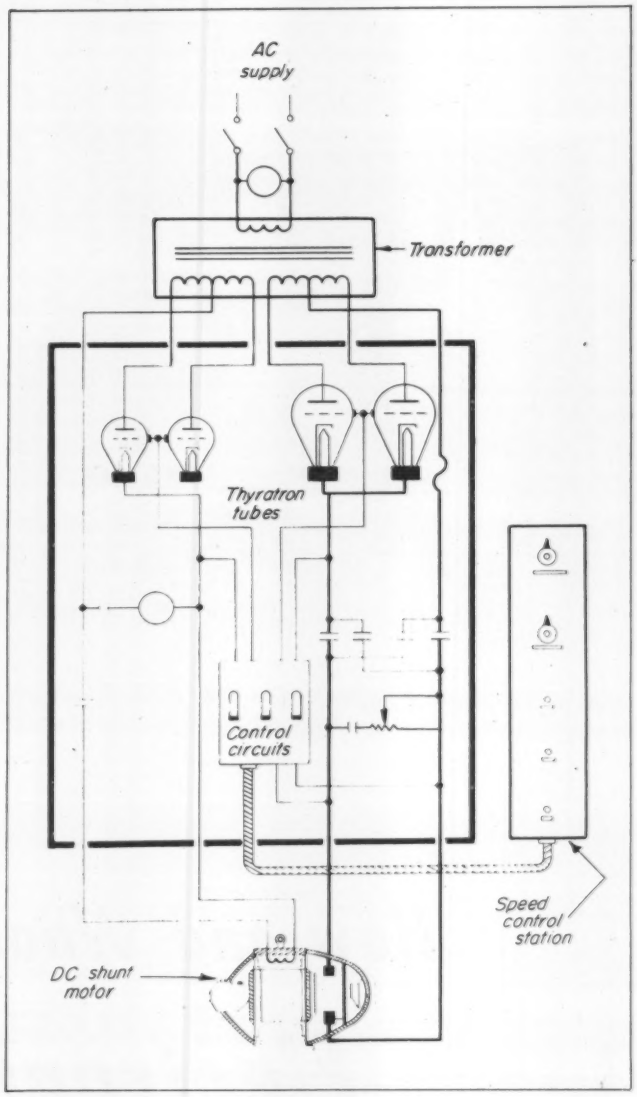


Fig. 1—Typical electronic adjustable-speed drive

TABLE I—**Motor Control Applications**

Drive Application	Method of Control									
	Armature Control	Field Control	Field & Arm. Power Conv.	Current Limit Acceleration	Automatic Speed Regulation		Reversing	IR Drop Compensation	Regeneration	Dynamic Braking
					Tach.Gen.	Arm.Voltage				
Winders	X	X	X	X	X			X		X
Coil winders	X		X							
Grinder feed	X		X	X		X		X		X
Lathe feed	X		X	X		X	X	X		X
Planer feed	X	X	X	X		X	X	X		X
Pulp grinder feed	X		X	X		X		X		X
Super centrifuge	X	X	X	X	X			X		X
Towing basin carriage	X	X	X	X	X		X	X		X
Slasher	X	X	X	X		X		X		X
Beam winder	X	X	X	X	X			X		X
Knitting machine	X		X	X		X		X	X	
Bag and package machine	X	X	X	X		X		X		X
Screw machine	X		X	X		X	X	X	X	
Printing press	X	X	X	X		X		X		X

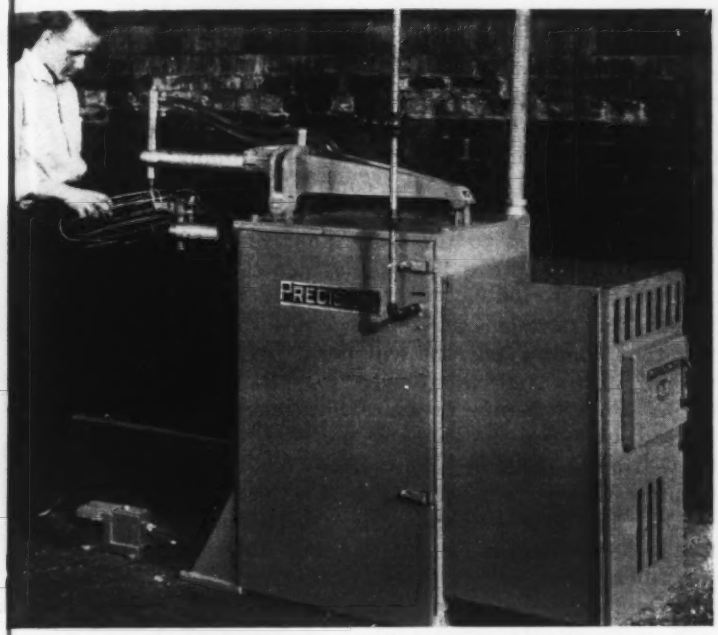
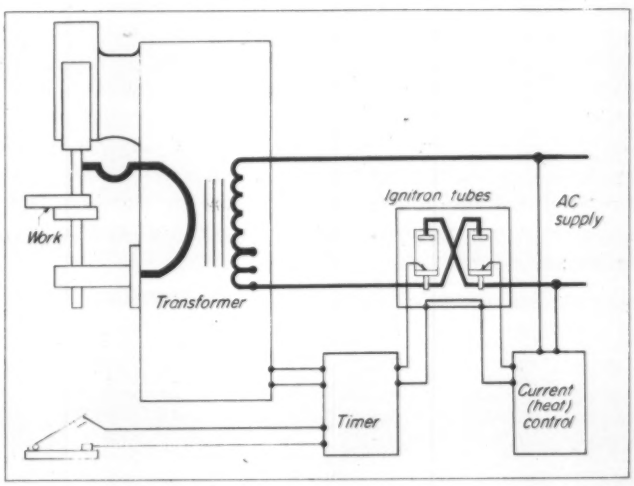


Fig. 2—Above—Welding control on spot welder measures current pulses for individual welds

Fig. 3—Below—Schematic arrangement of a spot welder and its control



from no load to full load the motor will be held to the preset speed. If the control is set for a given speed, it can be so adjusted that the speed will not vary more than two per cent from no load to full load. Normal variations in alternating-current voltage have only a slight effect on the speed regulation. In some drives, provisions are deliberately made so that the speed falls off rapidly with increase of load.

Many variations of the electronic adjustable-speed drive have been devised. These include a number of functional features such as speed adjustment, current-limit acceleration, automatic speed regulation, reversing, IR-drop compensation, regeneration, and dynamic braking. The function of speed adjustment is incorporated in all drives as this is the basic reason for using the dc motor. Features of the other functions are:

Current Limit Acceleration: This function limits the armature current to a preset maximum value that produces the desired accelerating torque. It also prevents exceeding the maximum motor or control rating

Automatic Speed Regulation: The signal for this function may be provided by the motor armature or by a tachometer generator. The latter is used when more precise speed control is necessary

Reversing: This is done with magnetic contactors for light and medium duty service and electronically for high duty applications

IR-Drop Compensation: A nearly flat speed-torque characteristic is provided over the whole speed range when armature voltage is used as a speed signal. This is not required when a tachometer generator is used

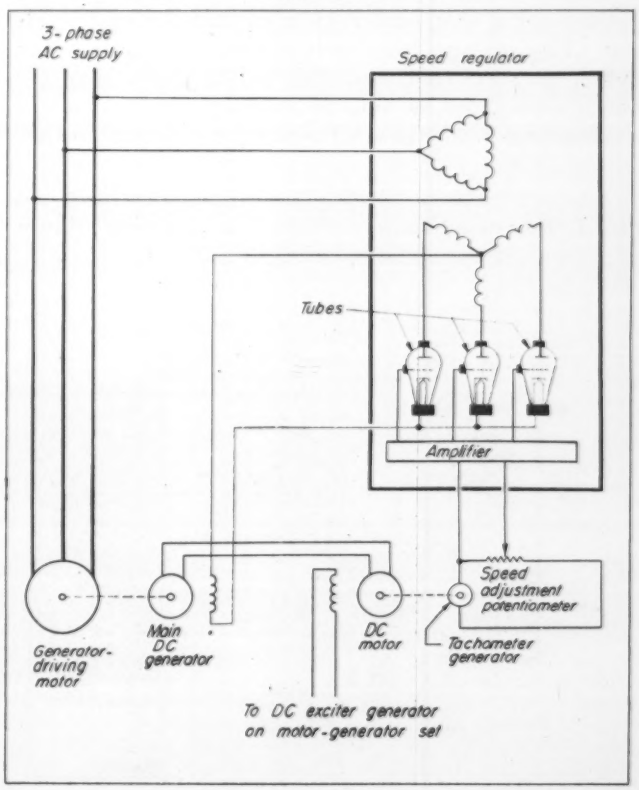
Regeneration: Rapid slowdown or reversal may be best accomplished by feeding power back into the ac line

Dynamic Braking: This function is usually accomplished by the contactor in the dc portion of the circuit connecting a resistor across the armature.

Applications which combine the available control features in various ways are shown in TABLE I.

TIMING: Time control is one of the most developed of electronic applications for it makes possible a high degree of precision. The ready adaptability of tubes

Fig. 4—Schematic arrangement of speed regulator in a motor drive



to the timing function is due to the small amount of energy required to operate them and to their long life under highly repetitive operation. The most common application of the timing function is in resistance welding. Here it is used to time not only the flow of welding current but also the mechanical sequence of the welding machine.

Resistance welding may be divided into several different general types including projection, butt, seam and spot welding, *Fig.* 2. Spot, projection, and butt welding differ only in the type of electrodes used and in the method of holding the materials during welding, all three using the same control units. These units measure out one or more pulses of current to make an individual weld.

Seam welding, however, uses roller electrodes, the control being quite different from that for spot welding. The current flows in individual pulses of a few cycles duration each and with a few cycles time between each pulse as long as welding is taking place.

Shown in *Fig.* 3 is a schematic of a typical resistance welding system for spot welding. The system consists of the welding machine with the welding transformer mounted in it and control equipment. The control is comprised of an ignitron power assembly for regulating the energy fed to the welding transformer, a timing control with four timing functions and the current or heat control. When the operator's foot switch is depressed, the welding electrodes are lowered to the work and, when pressure has been fully applied, the timing unit causes the ignitron tubes to conduct current to the welding machine. The timing control determines the length of time that welding current will flow. After the weld current stops, time is allowed for the weld material to solidify before pressure is removed from the electrodes. When the pressure has been released, the fourth timing function allows time for the operator to move the work pieces to a new location before starting the next welding cycle. Each timing function is adjustable to permit welding different kinds and thicknesses of material. The time values for each function are usually a small fraction of a second.

The ratings of welding control are based primarily upon the current carrying capacity as a function of duty cycle. The ignitron tubes serve as a power switch rated at currents up to 10,000 amperes during the weld at low-duty cycle. Inasmuch as the welding transformer steps current up several times, this value of primary current would correspond to perhaps 80,000 or 100,000 amperes in the weld itself. Most equipment operates from industrial voltages of 220 or 440 volts, although control is available for 2300-volt operation. The high voltage operation is particularly desirable for large welding machines to minimize the effect of the high current demand on the line voltage and in many cases to save on the amount of bus required for feeding the power to the machine.

TABLE II

Classes and Uses of Regulators

Type of Regulator	Variable Controlled	Typical Applications
Quantity	Voltage	Motor generators, rectifiers
	Speed	Wind tunnels, single-motor paper machines
	Frequency	Motor generators
	Current	Tension regulators, electroplaters
	Temperature	Furnaces
Position	Looping	Steel tinners, steel slitters, paper processors
	Winding	Manufacture of paper, steel, textiles; printing
	Slitting	Processing of paper, textiles, rubber and film
	Tin flow	Steel strip tinning lines
Quantity Matching	Speed	Paper mill drives, steel tandem rolling mills
	Register	Bag and packaging machines, color printing
Position Matching	Tracing	Electronic tracer

Fig. 5—Schematic diagram of a loop regulator system

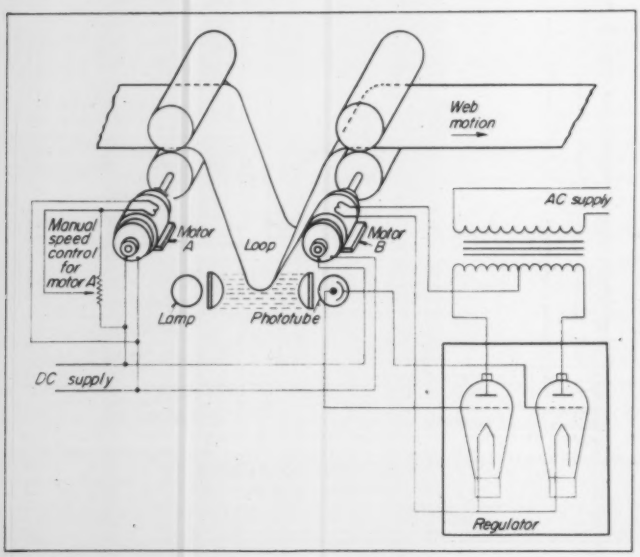
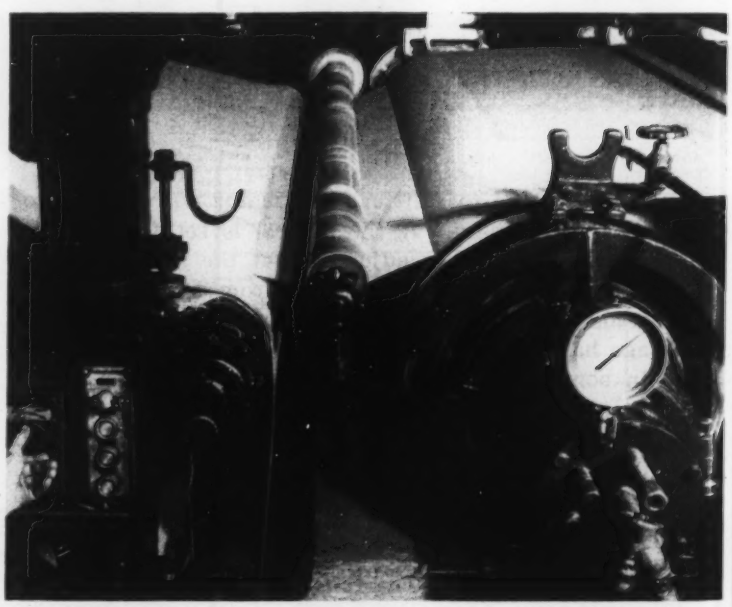


Fig. 6—Paper mill regulator controls speed of each roll



PROCESS REGULATION: Process regulation reaching into all industries is the most diversified of the many uses for electronic devices. However, it has found its greatest use in the continuous process industries such as steel, paper, rubber, packaging and printing. Regulators inherently operate continuously or very repetitively. Thus, they impose severe duty on any electromechanical device. The use of electronic circuits to perform the precision and repetitive functions materially improves the performance and reliability of the regulator. Many regulating problems such as automatic color register on multicolor presses could not be made automatic except electronically. Process regulators can be conveniently divided into four classes: quantity, position, quantity matching and position matching as shown in TABLE II.

Quantity Regulator: These devices regulate the magnitude of values such as voltage, current, frequency, speed, and temperature. A schematic for a speed regulator typical of this class is shown in *Fig.* 4. In this particular system, the dc motor is furnished with power by a motor-generator set. The generator field is energized from the electronic regulator. Motor speed is indicated by the tachometer output voltage which is proportional to speed. Indicating voltage is applied through the amplifier and regulating circuit to the grids of the rectifying tubes which furnish the generator field current. This device has found ready acceptance in paper mills for regulating the speed of a single motor paper machine drive. It maintains the speed to an accuracy of approximately 0.5 per cent and may be adjusted over a speed range of 10:1. A similar regulator is used to hold speed constant on the Wright Field 40,000 hp wind-tunnel drive.

Position Regulators: Position regulators maintain the location of a physical object within preset limits. A slitter regulator guides a web of material to a chosen location with respect to the cutter by photoelectrically watching the edge of the web or a line printed on the paper. A similar device will guide a web on a winder so as to reel evenly. The loop regulator on a paper-coating machine or on a steel strip mill watches the loop position and calls for slowing down or speeding up one of the mill sections to maintain a constant loop. The typical loop regulator system shown in *Fig.* 5 is a simplified arrangement used where the speed range is not more than about 4:1. The web is driven by motor *A* into the loop and taken out of it by motor *B*. Motor *A* and motor *B* can, for instance, operate two different sections of a conveyor or two separate stands of a mill. The speed of motor *A* is adjusted as desired, and the regulator then keeps the speed of motor *B* at the proper value to maintain a constant loop between the two sections. An increase of loop length reduces the amount of light reaching the phototube from the light source and modifies the field excitation of motor *B*,

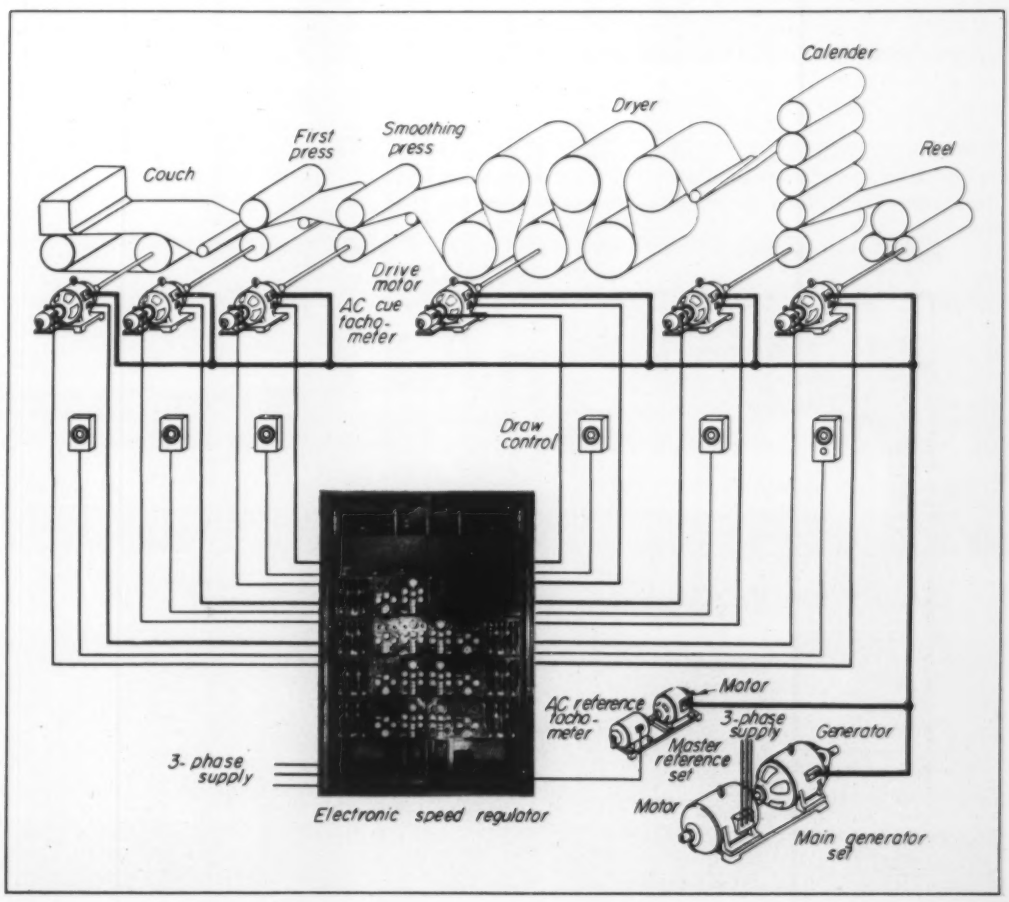


Fig. 7—Schematic diagram of sectional drive regulator for a paper machine

adjusting its speed, and bringing the loop back to the proper position.

Quantity Matching Regulators: These regulators are used to insure that two or more quantities match each other. Frequently, it is desired to adjust the speed, voltage, current or frequency of one element of a system and have one or more additonal elements equal or bear a chosen relation to the first element. This is especially important in continuous processing lines such as for steel, paper, rubber and photographic film.

An example of this type of regulator is the paper mill section drive regulator shown in *Figs.* 6 and 7. In this system, the speed of each section of the paper mill is regulated to a preset ratio with respect to the speed of a master reference. As shown in *Fig.* 6, the armature power for all of the section drive motors, as well as the motor of the master reference set, is furnished from a main motor generator. The overall mill speed is adjusted by the control of the field of this motor-generator set.

A cue tachometer is attached to each section drive motor. The regulator consists of a separate regulating circuit for each section of the mill. Each regulator compares the speed indication from the master reference with that from the cue tachometer for that section. The regulator supplies the correct field current to each driving motor to maintain a chosen speed ratio between master and the section. An accuracy of match of $\pm$ 0.05 per cent is maintained.

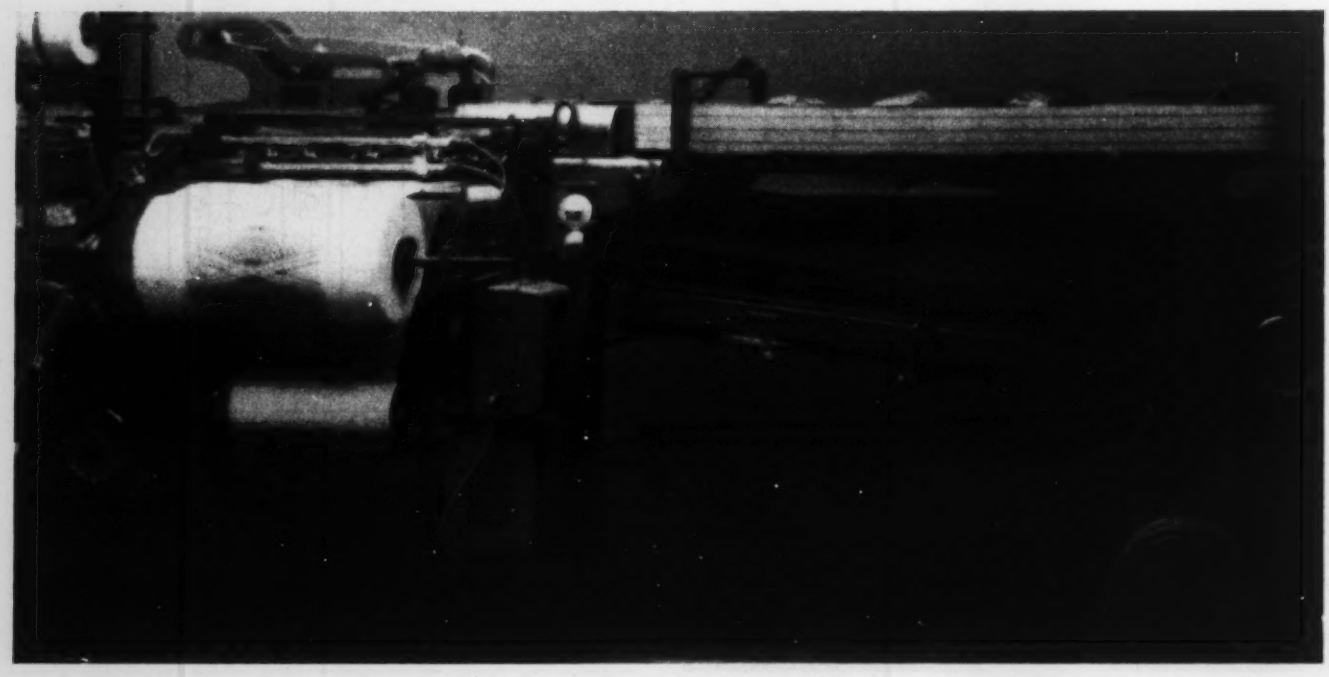
Operating results over 20 years on a sectional drive paper machine controlled by an electronic speed matching regulator show an increase in production, extremely uniform draws, and a greater flexibility and stability of the paper machine drive.

Position Matching Regulators: A regulator used frequently in the paper, cellophane, and glassine packaging industry is that for maintaining the position of cut when unrolling preprinted stock for making bags and packages. Although the machine feeds paper at a rate approximately correct to match the speed of the cutter knife, the cut will never remain registered perfectly without either manual or automatic supervision. A register regulator corrects for minor changes of paper slippage, stretch, and speed relative to the cutter speed. The position of the printed material is indicated by a rectangular register mark in the design or margin which is scanned by a phototube. The position of the mark with respect to the cutter is checked and the speed or amount of paper feed modified if necessary. A typical installation of this type, shown in *Fig.* 8, is for packaging bread.

Printing Press Application

Another important application for this class of regulator is for maintaining the register of the several colors in a multicolor printing press. In this system, yellow is printed in the first press section and each succeeding press section adds another color, the location of which must be accurately matched to the original yellow. As the yellow is printed, a series of yellow register marks is simultaneously imprinted on the paper web. A scanner at each succeeding press section detects the position of the yellow register mark. The regulator then compares the scanner signal with that from a reference pickup attached to the printing cylinder, making adjustment to match the time of occurrence of the two signals. A register accuracy of approximately three-thousandths of an inch is maintained.

Fig. 8—Bread wrapping machine with photoelectric control cuts paper to place trademark at same spot on loaf



MACHINE DESIGN
A PENTON PUBLICATION

Keeping Abreast

TWELVE YEARS AGO this month MACHINE DESIGN published a supplement which was the forerunner of the annual Machine Drives and Controls issues. The intervening years have witnessed tremendous strides in this field; designers can now choose from a wide variety of elements and systems those that will best fit the job at hand.

Although the largest volume of drive and control equipment is applied to the adaptation of electric power to the manifold requirements of machines and appliances, the most spectacular new developments lie in the field of prime movers. A dozen years ago, for instance, the gas turbine was little more than a gleam in the eye of a few pioneering enthusiasts. A dozen years hence it may well be an important source of power for a multitude of new machines. Instead of simplifying the designer's problems, however, the gas turbine is likely to multiply them.

If past experience is any guide, the problems posed by new prime movers and new machine requirements will not be solved overnight. Of all the branches of machine design none have suffered more from "growing pains" than drives and controls—mechanical, hydraulic, electrical, electronic, pneumatic. Inevitably some early designs have proved to be less than satisfactory. Consequently an engineer who has been "stuck" with a poorly designed hydraulic system or electronic control can hardly be blamed for taking a somewhat skeptical view of the whole field of hydraulics, or electronics, as the case may be. Healthy skepticism should be part of the makeup of all good engineers, but it should not mean a closed mind. New knowledge and broader experience are constantly being applied to the improvement of design, and in the highly competitive days which are upon us no designer can afford to neglect the possibilities of some system simply because of prejudice based on an experience which may be ancient history, relatively speaking.

Periodic review of the whole field is a "must." It is hoped that by highlighting developments the continuing series of Machine Drives and Controls issues, of which this is the latest, will go a long way toward helping designers keep abreast of current trends.

Colin Carmichael

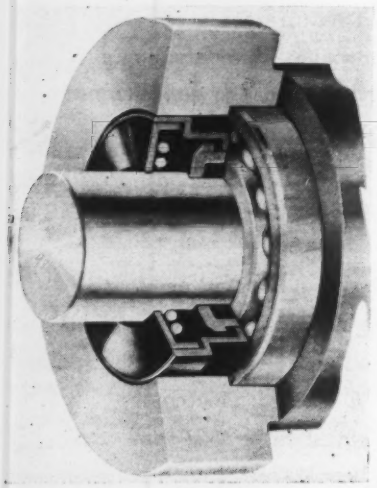
EDITOR

new parts and materials

For additional information on these new developments see Page 311

Rotary Oil Seal

Bearing oil seal has rotating and stationary surfaces contained in a metal cartridge, permitting ready integration with designs. This device, known as the Gits Unit Seal, utilizes a radial seal joint which does not wear on the shaft or bearing race. Factory positioned, the seal surfaces will remain in contact without warping. Manufacturer: Gits Brothers Mfg. Co., 1486 S. Kilbourne Ave., Chicago 23.



For additional information circle MD 1 on Page 311

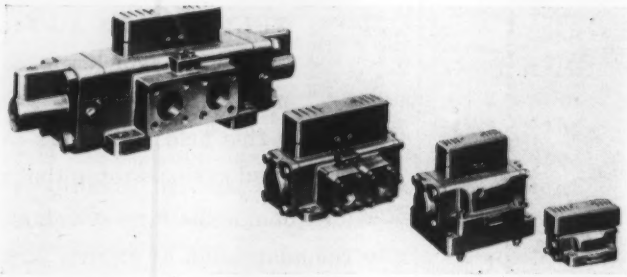
High-Density Bearing Bronze

High-purity, high-density bearing bronze, meeting SAE specification 660, has low porosity and is free of dross and sand inclusions. This material, tradenamed Asarcon 773, is supplied in sizes ranging from ½ to 4½ inches in diameter in solid rounds and in tubing ranging from ½ by 1 to 3¼ by 4¼. Lengths are not standard; sizes being dictated by the customer. Manufacturer: Ampco Metal Inc., 1745 S. 38th St., Milwaukee 4.

For additional information circle MD 2 on Page 311

Directional Control Valve

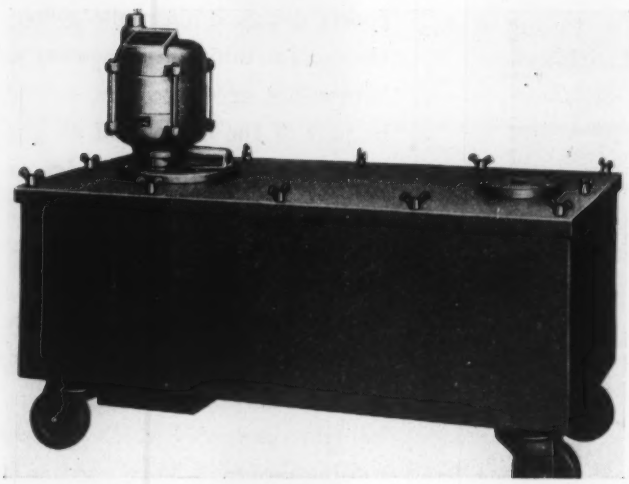
Series DG solenoid-operated directional control valves are made in 2, 3 and 4-way types. Features of the valves are compactness, low inrush and holding current, and small solenoids. Maximum operating pressure is 2000 psi. Units are made in sizes from ⅛ to 1¼ inches in styles for either gasket or screw connections. Models for flange connection are made in sizes from 1½ to 3 inches. Manufacturer: Vickers Inc., 1430 Oakman Blvd., Detroit, Mich.



For additional information circle MD 3 on Page 311

Explosion-Proof Pump Motor

Suitable for use with all sizes of Gusher pumps, new polyphase motors are made in ratings of ¼, ½ and ¾ horsepower. The motors are suitable for use in hazardous locations, meeting Underwriters' Laboratory test for Class I, Group D service. Model U1-7124-EXP is shown installed on a totally enclosed portable tank for pumping highly volatile printing inks. Manufacturer: Ruthman Machinery Co., Cincinnati 2.



For additional information circle MD 4 on Page 311

Flexible Coupling

Synthetic rubber inserts as used on new flexible couplings designed for quiet operation. Units are provided with standard keyways for use with shafts

The Lubrication of Sleeve Type Bearings-I

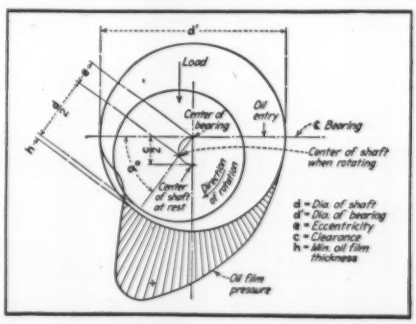
EFFICIENT bearing performance is governed to a great extent by the selection of the bearing material, the bearing design and the method of lubrication. By determining these factors, in relation to the operating conditions, we have the basis for the selection of the proper bearing to deliver the desired performance.

In consideration of the lubrication factor, we must determine the following points: Speed, load, viscosity of lubricant, bearing material, clearance, bearing design, nature of the rubbing surfaces, operating temperature and method of feeding and distribution of lubricant.

While the primary purpose of lubrication is to eliminate mechanical friction and to prevent wear and corrosion, no appreciable amount of power can be transmitted on the best of bearing materials without definite lubrication. Heat develops rapidly when the shaft operates in direct contact with the bearing. Heat is also developed beyond the normal radiating capacity if the viscosity of the lubricant is too high in relation to the speed of the shaft.

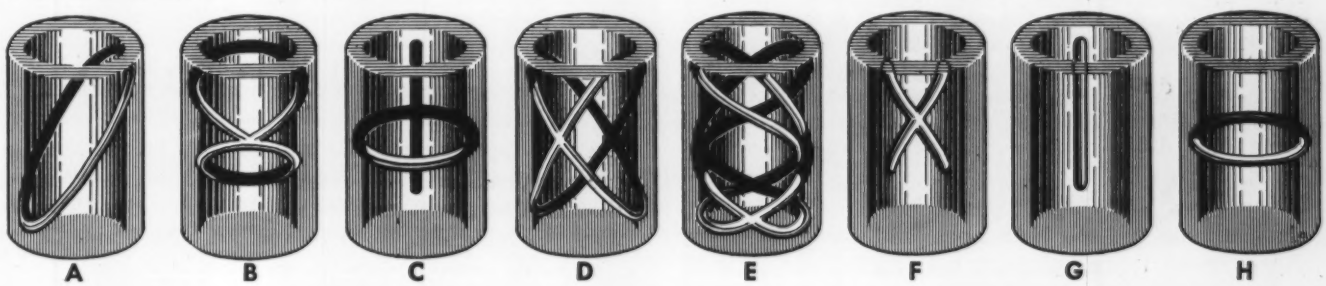
It is a mistaken idea that any type of oil or grease will provide suitable lubrication. The extensive research accomplished by the producers of lubricating materials enables any user of bearings to select the exact type required for his applications. In certain applications it is necessary to provide protection to the lubrication by the use of seals or the design of the bearing. This prevents the lubricant from seeping out with consequent loss and damage to material in process.

With the starting of the shaft the frictional resistance is high. As the speed increases, the lubricant under the influence of the moving part, plus its adhesive qualities, builds up a relatively thick film between the surfaces at the point of nearest approach. The shaft then undergoes a displacement in a direction at right angles to the line of load. The continued speed of the shaft creates a film pressure which increases until an equilibrium is established.



* * *

THE CURVE, as shown at left, represents the distribution of the calculated values of pressure in relation to the bearing reaction. The load-carrying capacity is governed by the maximum pressure that can be developed under the existing conditions. If the load pressure is down—as illustrated—then the curve indicates that the lowest pressure is practically opposite. Obviously this is the proper place for the intake of the lubricant.



Oil Grooving

● The purpose of oil grooves is to assure proper distribution of the lubricant along the length of the bearing in the region just ahead of the loaded area (see above). Complicated and elaborate grooves are in most bearings neither necessary nor useful; they render manufacturing more difficult, and, if not properly placed and executed, may do more harm than good because they may assist in interrupting the oil film.

Deep grooves should always be avoided and both edges of any oil groove should be rounded off to permit free entrance of the oil into the clearance.

Grooves should never be located in the high-pressure area of an oil lubricated sleeve bearing.

In order to obtain quick and uniform distribution of the oil along the length of the bearing, the oil groove should extend axially from the point of entrance and should stop short of the ends of the bearing to minimize oil leakage.

In applications where the direction of rotation changes, spiral oil grooves approaching the high-pressure area, like those shown in (a) and (b), might be expedient.

In many types of split-half bearing, especially when pressure lubrication is used, longitudinal chamfers (relieves) on each side of the bearing halves, are sufficient to secure distribution along the length of the bearing.

As to the points of the oil entry into the oil grooves, they should always be located ahead (relative to the direction of the shaft rotation) of the pressure area; that is, in the unloaded side in bearings with constant load direction.

In applications with changing load direction, the oil entry should be placed at points of minimum oil pressure.

For very long bearings, two oil entrances might be expedient or necessary; if so, they should be connected by one axial distributing groove.

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

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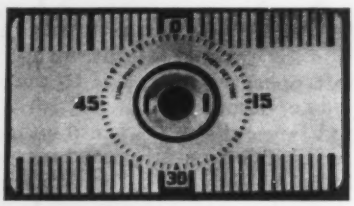
from 3/8 to 1½ inches in diameter, and with setscrews for locking in place. Features are nonlubricated operation and freedom from harm by oil, dust or dirt. Manufacturer: Boston Gear Works, Quincy, Mass.

For additional information circle MD 5 on Page 311

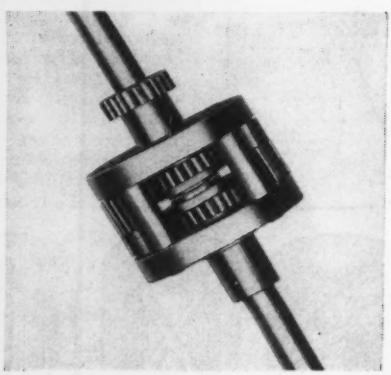
Timer Dials



Six new dials for use with Mark-Time timers are designed for eye appeal and service. Fabricated of heavy gage, chrome-plated brass to assure corrosion resistance, dials have one minute graduations with every fifth-minute-graduation emphasized. Each dial has been designed to use the center stud method of mounting and aligning the timer and dial in one operation. Manufacturer: M. H. Rhodes Inc., Hartford, Conn.

For additional information circle MD 6 on Page 311

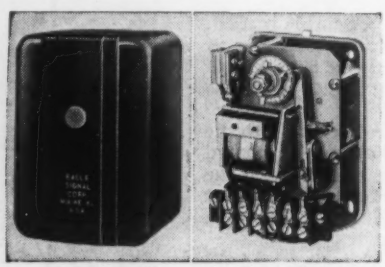
Small Mechanical Differential



Precision mechanical differentials are suitable for use in measurement and control mechanisms. The units can be used in controlling relative speeds, speed sums and differences, angular sums and differences, speeds, torques, etc. Models available include both open and jacketed types, the enclosed types being grease lubricated. A wide range of sizes and constructions can be made. Manufacturer: Milwaukee Lock & Mfg. Co., 5038 N. 37th St., Milwaukee 9.

For additional information circle MD 7 on Page 311

Electric Timing Unit

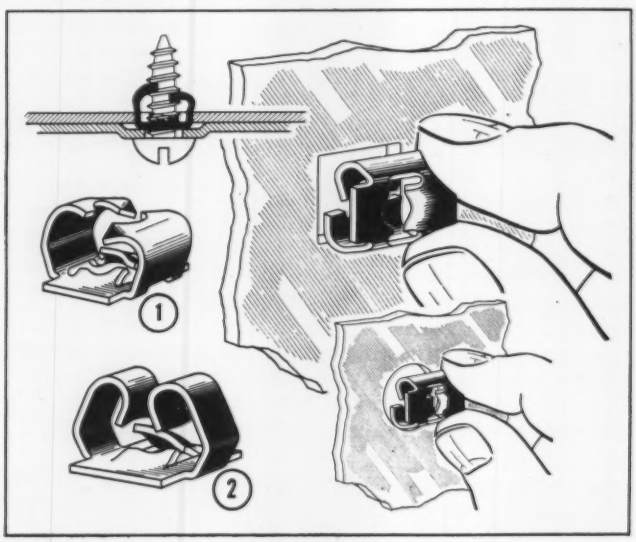


Timoflex electric timer will provide timed closing or opening of electrical circuits. Made in three types, the first starts timing when a pilot switch is closed, the second times from the opening of the switch, while the third operates from momentary closing of a pushbutton. Operation is by a slow-speed synchronous motor with a separate reset coil to release the timing mechanism. Standard timing scales cover 55 seconds, 5½ minutes, 27½ minutes or 55 minutes. Mounting space covered measures 3 by 4½ inches; Bakelite cover is provided. Manufacturer: Eagle Signal Corp., Moline, Ill.

For additional information circle MD 8 on Page 311

Blind Fastener

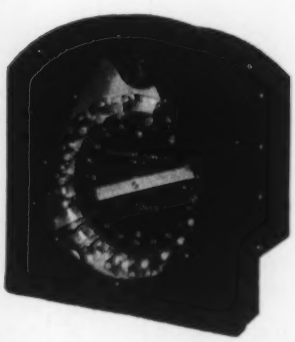
Expansion Speed Nuts permit the use of screws in blind locations. The nuts are inserted from the front into square or round holes in sheet metal panel securing themselves by expansion of wings as the screw is driven home. Two types are available. The



first has spring arms formed to grip at the root of the screw thread, while the second has curved arms that ride on the thread crests. Manufacturer: Tinnerman Products Inc., 2035 Fulton Rd., Cleveland 13.

For additional information circle MD 9 on Page 311

Process Timer



New timer is suitable for use with operations bearing a percentage relationship to the total time cycle. This type DB control eliminates need for a number of timers arranged in cascade, and requires less auxiliary control apparatus. Unit consists of motor driven control arm moving around a calibrated scale bearing adjustable contacts. Arm makes and breaks each contact in succession. Feature of the unit is reliability of the adjustable-speed drive used with the

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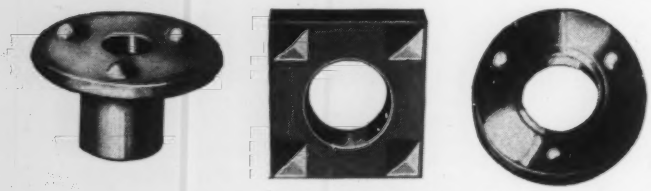
motor; stepless drive has high accuracy in the speed range of 36:1. Timer is adaptable for continuously-repeating, single-cycle or interrupted-cycle processes. In can be changed over to control various processes. Manufacturer: Struthers-Dunn Inc., 150 N. 13th St., Philadelphia 7.

For additional information circle MD 10 on Page 311

Projection Welding Bosses

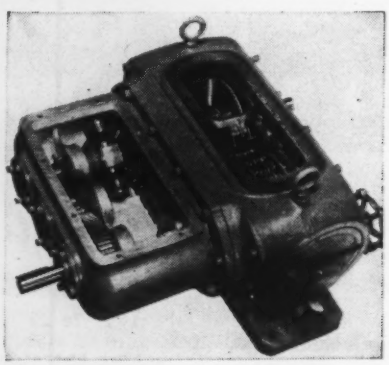
Projection welding bosses are suitable for use in reinforcing sheet metal parts to allow for shafts, fastenings or spacers. The bosses are made in round, square and flanged shapes up to one inch in width or diameter and ¾-inch thick. Hole diameters range



from 0.104 to 0.638-inch. Materials include brass, low carbon steel and 18-8 stainless. Manufacturer: Ohio Nut & Bolt Co., 33 First Ave., Berea, Ohio.

For additional information circle MD 11 on Page 311

Variable-Speed Transmissions

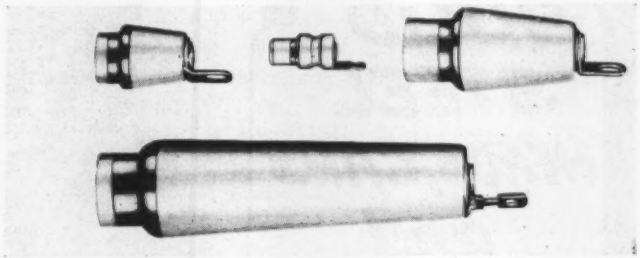


Variable-speed transmission tradenamed Specon MD will provide infinitely variable speeds between 0 and 7000 rpm forward or reverse. Four models are available to provide torque outputs from 20 to 15,460 lb-in., and horsepowers from 1 to 20. Desired speed is set by a hand wheel and indicated on a large dial. A vernier scale is provided, when desired, to permit close speed settings. Typical applications of the transmissions include the cloth, paper and strip-steel industries. Manufacturer: Speed Control Corp., Dept. C-8, Wickliffe, Ohio.

For additional information circle MD 12 on Page 311

Hermetically-Sealed Terminals

Line of hermetically-sealed steatite electrical terminals are tinned for ready application to metal enclosures. These terminals are a glazed ceramic that is tough, will not crack under rough handling and is resistant to failure under thermal shock. Leads are



brought through an axial opening and soldered to a tinned lug provided at the end of the bushing. Manufacturer: General Ceramics and Steatite Corp., Keasbey, N. J.

For additional information circle MD 13 on Page 311

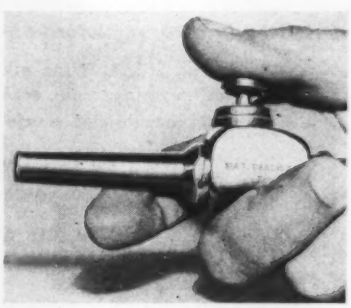
Mechanical Counters

Line of stroke and rotary counters is made in reset and nonreset types. Four styles available will count to 1000, 10,000, 100,000 and 1,000,000. Figures on these Series Y counters are black on white background, the figures measure 0.166-inch high and 0.097-inch wide. Length of the counters ranges from

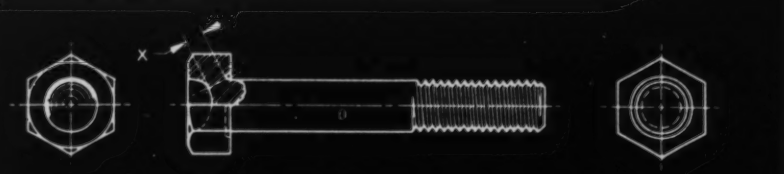
1 1/16 to 2¼ inches, depending on the number of figures. Bearings are of the oilless type, shafts are stainless steel and window is plastic. A single turn of the knob resets all figures to zero. Manufacturer: Durant Mfg. Co., 1933 N. Buffum St., Milwaukee 1.

For additional information circle MD 14 on Page 311

Air-Hose Valve



General purpose air-hose valve and nozzle has no springs or packing. Springs have been obviated by an adaptation of the venturi tube; a ball check is pulled into its seat at the narrow part of the tube by the low pressure at that area. To open the valve, a plunger is pressed, deflecting the ball from its seat. As long as the plunger is held down, the ball is away from the air stream and the



The "Place" type head is formed with a cup-like recess in its upper face and a circular recess in its under face adjacent to the shank. Between the radii of these recesses is formed a diaphragm (x) which acts as a spring element when the head is wrenched tightly against a rigid base.

U. S. Patent No. 1966044

DIAPHRAGM HEAD MAKES PLACE BOLT self-locking against VIBRATION

Critical problems of fatigue and involuntary loosening on automotive, aircraft, farm equipment, and other products have been effectively met by *self-locking* Place Bolts.

The unique "diaphragm" head design (see illustrations) produces an axial spring tension when the bolt is tightened, giving it extraordinarily high vibration resistance. Place Bolts may be used with nuts or in tapped holes, but should be used only where it is possible to tighten against a rigid seat.

Made of alloy steel, heat-treated to high physical properties, Place Bolts can be furnished in a wide range of sizes and may be developed for special applications. Typical examples include connecting rod bolts, main bearing cap screws, flywheel bolts and piston pin lock screws.

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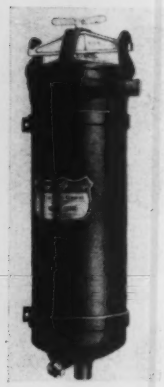
3421 S. Garfield Ave., Los Angeles 22, Cal.

valve is open. Upon release of the plunger the ball is forced into its seat by air pressure. Since ball motion is largely rolling, wear is small and evenly distributed. Seal is the O-ring type, valve body is stainless steel. Units are made in ⅛ and ¼-inch sizes, both have bodies tapped for standard ¼-inch pipe threads. Manufacturer: Paul Valve Corp., 683 3rd Ave., New York 17.

For additional information circle MD 15 on Page 311

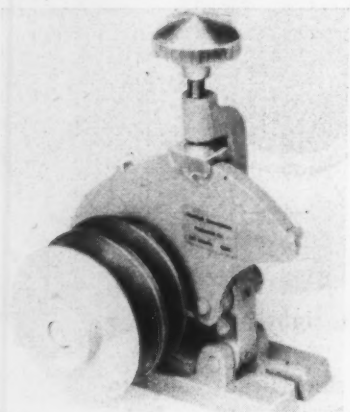
Dual-Purpose Filter



Filter known as the C. T. Clarifier operates efficiently in cleaning lubricating or fuel oil. Unit employs a replaceable filter cartridge which can be changed without the use of tools. An outside-to-center flow type, filter has an area equal to 272 square inches when used for lubricating oil and 238 square inches when fuel-oil cartridges are used. In the former application, governing orifice is removed to allow a free flow. Manufacturer: W. G. B. Oil Clarifier Inc., Kingston, N. Y.

For additional information circle MD 16 on Page 311

Variable-Speed Transmission

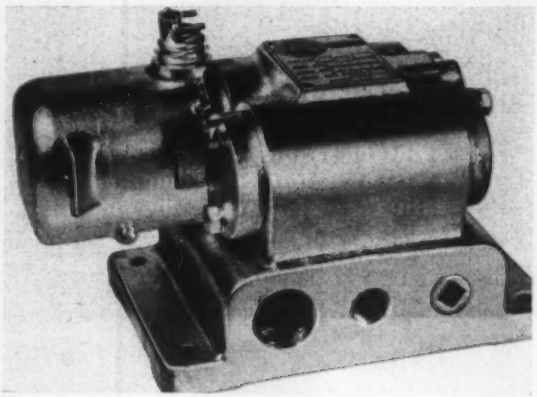


Smallest of the Cub line of transmissions, new variable-speed unit is designed for applications requiring no more than a 3.3:1 speed range and power output within the capacity of A-section V-belts. Frame is cast iron with base dimensions of 2¾ by 7½ inches. Overall width is 6½ inches and height is 9 inches. Speed is adjusted by lever control. Features of new transmission are use of hardened and ground shaft, and sealed doubled ball bearing assemblies, resulting in long life and high power output. Manufacturer: Standard Transmission Equipment Co., 78 W. Union St., Pasadena 1, Calif.

For additional information circle MD 17 on Page 311

Solenoid Air Valves

Line of Ring-Seal direct-acting solenoid air valves have fully interchangeable parts. Standard poppet assemblies are used on valves of all sizes, whether they are three or four way, and irrespective of the number of ports. These assemblies are of the double-opposed type, completely balanced, reversible and removable from either end of the housing. Bodies are aluminum, while assemblies are stainless steel or bronze. Units operate on 110-volt, 60-cycle current,



and may be used at pressures up to 105 psi. Manufacturer: Viking Products Co. Inc., 2373 E. Eight Mile Rd., Hazel Park, Mich.

For additional information circle MD 18 on Page 311

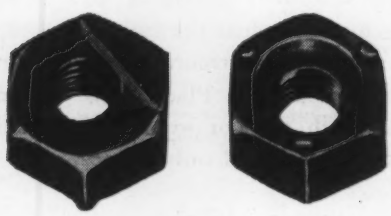
DC Power System

Six-volt rectified ac alternator systems are now being made in 45 and 80 ampere ratings. Both of the new ratings feature the same high-output characteristics of the older 60-ampere system. When automotive engine is idling, output is 25 to 35 amperes. At 12 to 15 mph, output is maximum. Manufacturer: Leece-Neville Co., 5363 Hamilton Ave., Cleveland.

For additional information circle MD 19 on Page 311

Locking Weld Nut

Designed for projection welding to sheet metal, the Gripco weld nut has three base projections to assure firm nonrocking connections in welding. Thread fouling by weld spatter or flash is overcome by the



use of a counterbored section at the base of the nut, metal particles falling upon this surface rather than upon the threads. Thread height, however, is the same as that of standard nuts, the overall height of the fastener having been increased to provide for the counterbored section. Locking is achieved by

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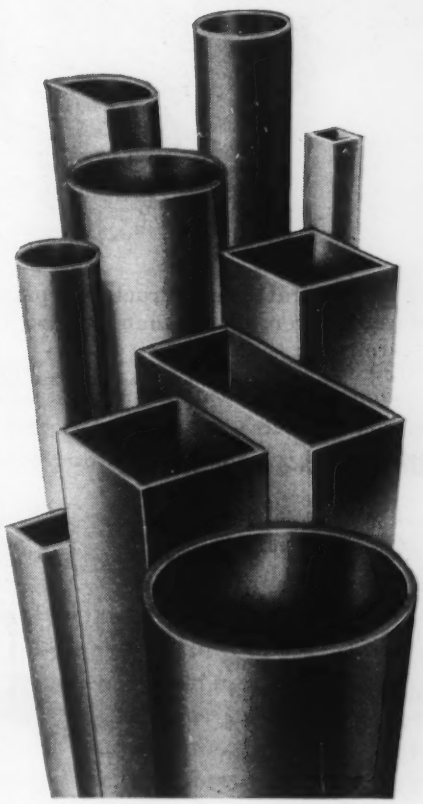

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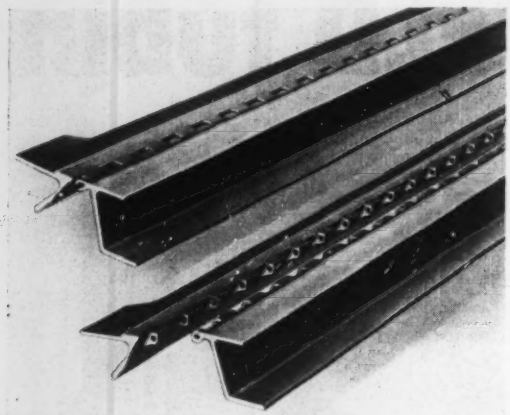
means of depressions coined into the top of the nut, tightening sections of the upper threads. Manufacturer: Grip Nut Co., 310-W S. Michigan Ave., Chicago 4, Ill.

For additional information circle MD 20 on Page 311

Continuous Aluminum Hinges

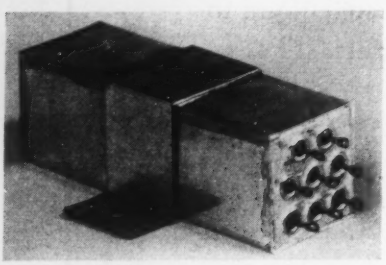
Extruded aluminum hinges are available in continuous lengths up to 12 feet. Made of 24ST and 75ST alloys, the hinges have high strength and may



be incorporated as structural parts of assemblies. Manufacturer: Moynahan Bronze Co., 9072 Apline, Detroit.

For additional information circle MD 21 on Page 311

Ultra-High-Speed Relays

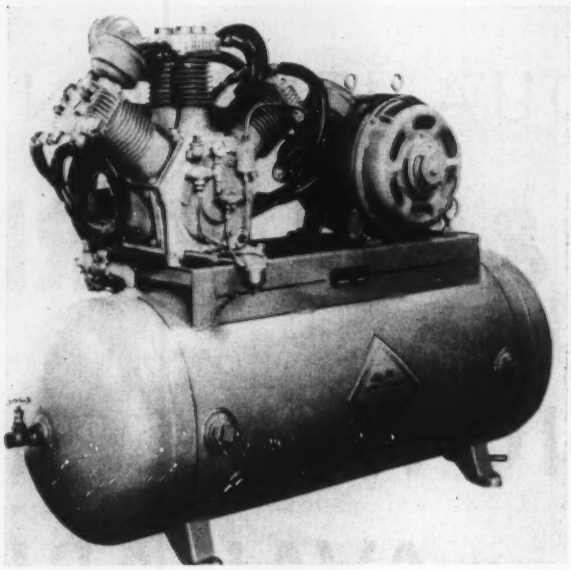


Formerly available as single-pole, double-throw units, Millisec high-speed relays are now made in a 4-pole, double-throw style. These new hermetically-sealed relays will operate at speeds as high as $^1/_3$-millisecond and have a life expectancy of 22-100 million operations. They have a contact rating of 110 volts, ½-ampere, dc. Light weight and compact, the relays are recommended for use on such apparatus as business machines and high-speed computors. Manufacturer: Stevens Arnold Inc., 22 Elkins St., South Boston 27, Mass.

For additional information circle MD 22 on Page 311

Air Compressor

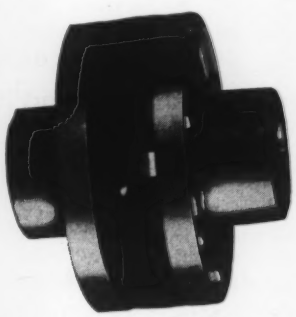
Line of air compressors is available in 48 different models using only 18 different parts. Interchangeability of parts irrespective of the size of the compressors, reduces replacement inventory and simplifies repair problems. Ratings of the compressors range from ½ to 40 hp with capacities ranging from 2.5 to 275 cfm at 30 to 300 psi. Vertical, side-angle



or V-type units are available with single, twin or radially-staggered cylinder arrangements. Manufacturer: Air-Flo Compressor Co., Akron 7.

For additional information circle MD 23 on Page 311

Flexible Couplings

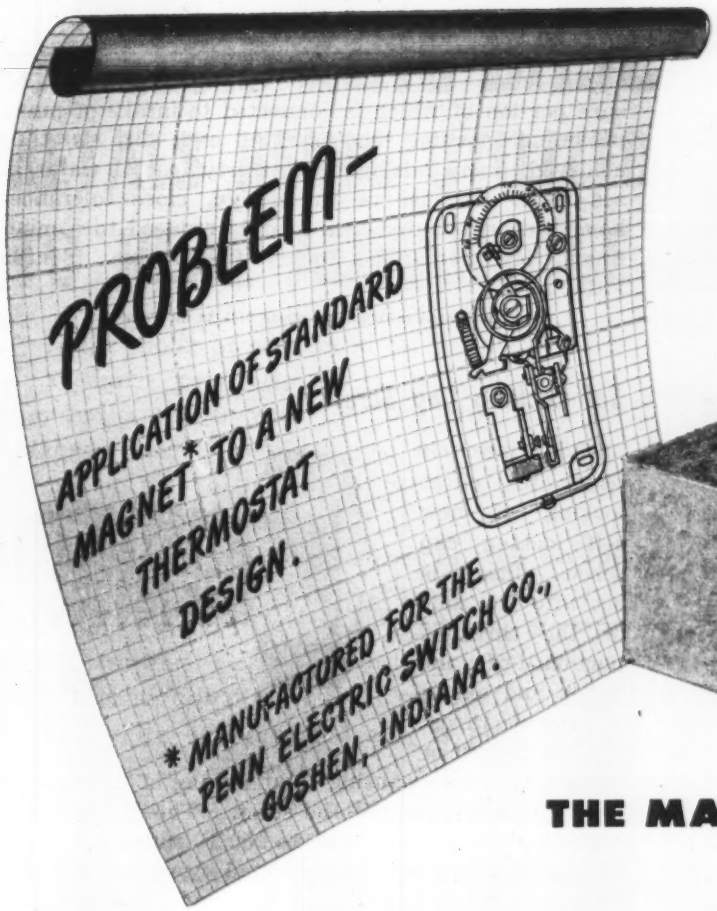


Line of flexible couplings are now available in ratings from $^1/_{50}$ to 100 hp at 1750 rpm. The couplings ranging from $^1/_{50}$ to 15 hp have 15 degree torsional deflection under rated load; sizes 30 to 100 hp have 3-degree deflections. This high angular deflection is said to give unusual vibration isolation. The neoprene flexing elements operate in shear and are bonded to steel plates, there are no bearing surfaces and couplings require no lubrication. They will accommodate at least 2-degree angular and $^1/_{32}$-inch parallel misalignment. Manufacturer: Lord Mfg. Co., Erie, Pa.

For additional information circle MD 24 on Page 311

Cast-Iron V-Belt Pulleys

New line of cast-iron pulleys is available in 26 sizes and 101 combinations of groove diameters and bores. These gray-iron V-belt pulleys are provided with keyways and Allen set screws. Groove angles are held at 34 degrees. The units are shot peened to



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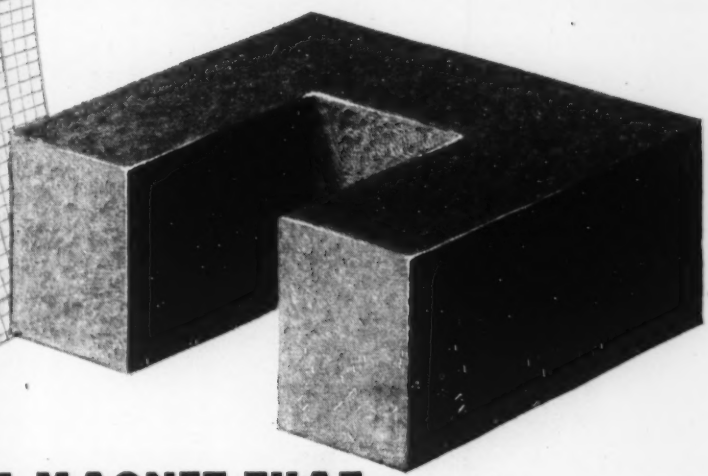
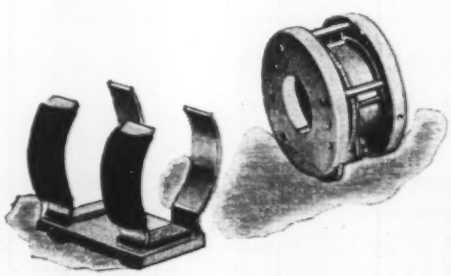


THE MAGNET THAT *Heats Your Home*

Here's a magnet that's simple in design yet is the heart of Penn room thermostats. . . . thermostats which *anticipate* heat requirements before temperature *changes.* The Sintered Alnico 2 permanent magnet snap-acting contact mechanism responds almost instantly to temperature variations.

This application is an excellent example of cost-saving by using stocked G-E permanent magnets. Since the magnet is stocked there are no special tool charges. And orders for stocked magnets are filled quickly, eliminating costly production slow-downs to you.

Perhaps a standard listed magnet can be used in your applications. And if a standard G-E permanent magnet will not meet your requirements, our engineers will be glad to design one specially for you. Remember, too, that General Electric manufactures all grades of cast and sintered Alnico as well as special magnet alloys.



G-E Permanent Magnet SUB-ASSEMBLIES

Here's a new product which may lower your permanent magnet costs. Permanent magnet component assemblies are specially designed to your specifications—ready for immediate installation in your final product. All permanent magnets are mounted for maximum efficiency. And, assembly and calibration operations are completely eliminated at your plant. For your free copy of General Electric's new bulletin on G-E Permanent Magnet Sub-assemblies mail the coupon shown below.

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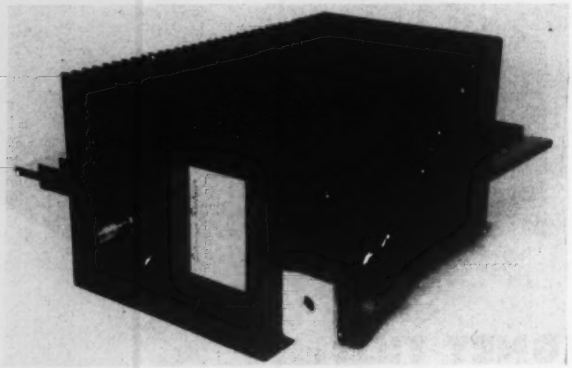
provide a clean smooth surface and to provide high strength. Manufacturer: A & A Machine Co., Warsaw, Ind.

For additional information circle MD 25 on Page 311

Heavy-Duty Selenium Rectifiers

Selenium rectifier stack will deliver 1500 amperes and 9 volts under continuous load, operating on three-phase, half-wave power. The stack consists of thirty-



four 6¼ by 7¼-inch selenium elements, each waterproofed and mounted so as to allow good air cooling. Terminals are ¼ by 1½-inch copper busses. The entire unit is rigidly assembled and is suited for installation on mobile as well as stationary units. Manufacturer: International Rectifier Corp., 6809 S. Victoria Ave., Los Angeles 43.

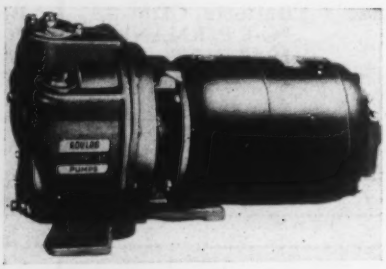
For additional information circle MD 26 on Page 311

Sanitary Rubber Hose

White oil-resisting rubber hose for food-handling equipment will withstand abrasive service. The material is made in 25 and 50-foot lengths. Hose of similar construction but with black cover is made in continuous lengths up to 450 feet. Manufacturer: Goodyear Tire & Rubber Co., Akron, Ohio.

For additional information circle MD 27 on Page 311

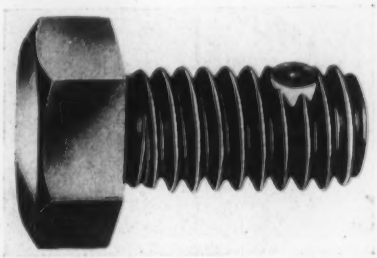
High-Head Jet Pumps



Combination centrifugal and jet pumps are designed for high pressures at low capacities. Made in sizes from ¼ to 5 hp, the pumps are rated 35 gpm at pressures up to 190 psi. Pressure build-up is in two stages: Liquid discharged from centrifugal portion of the pump passes through nozzle-diffuser system, the low-pressure portion of which is connected to intake of pump providing positive suction. A high lift is thus achieved, pump raising up to thirty feet of water at sea level. Because of the design, close tolerances have been eliminated and wear is reduced to a minimum. Manufacturer: Goulds Pumps Inc., Seneca Falls, N. Y.

For additional information circle MD 28 on Page 311

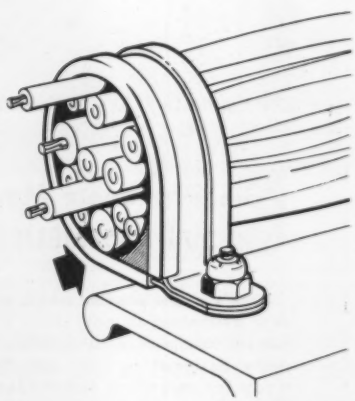
Self-Locking Cap Screw



Nylon insert is used to effect locking of new self-locking cap screw. Insert is set into the side of the threaded portion of the screw and exerts a lateral thrust against the nut or tapped hole, thus causing tight mating of the threads on the opposite side of the screw. The fastener will withstand temperatures up to 250 F, suffer no loss of torque on reuse, and is unaffected by water and ordinary solvents. It meets Army and Navy aircraft specifications of torque and vibration resistance. Manufacturer: Diamond Head Screw Corp., 6715 Hollywood Blvd., Los Angeles 28.

For additional information circle MD 29 on Page 311

Wire Harness Clamp



Principal feature of the type TA-710 electrical harness clamp is the use of an integral rubber wedge which locks wires within a complete ring of rubber. As a result, the wires cannot touch metal and be short circuited. Wires, therefore, need not be taped and can be handled as loose bundles prior to clamping in place. The clamp is available in sizes from ¼ to 4 inches in steps of 1/16-inch. Manufacturer: Thomas Associates, 4607 Alger St., Los Angeles 26, Calif.

For additional information circle MD 30 on Page 311

Electronic Load Control

Suitable for use with motor-operated devices such as pumps, pulverizers, extruders, etc., the Flexitrol electronic control maintains a constant motor load by

Wichita City Library

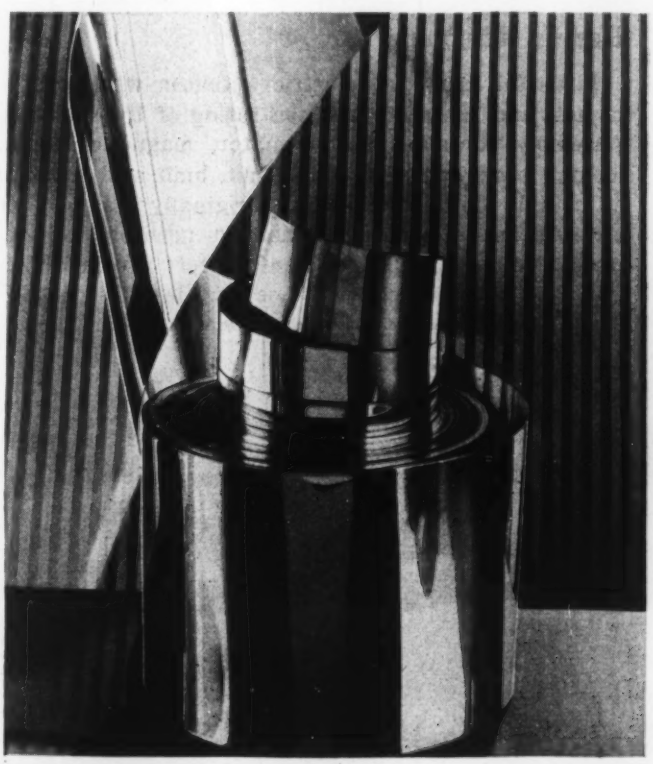
NICKELOID ZINC BASE METALS BEING UTILIZED TO REAL ADVANTAGE

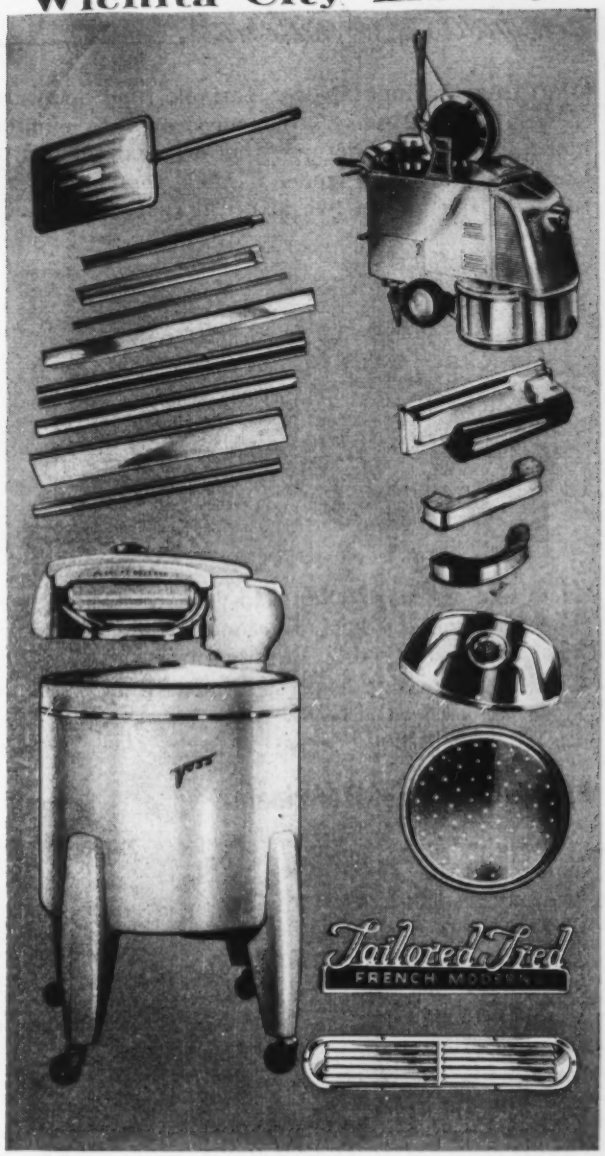
In the choice of base metal for pre-plated parts on consumer products, the manufacturer many times has a tendency to overlook the many advantages of zinc. In purchasing his plated sheets or coils he may first think of steel or aluminum base — or brass and copper.

In cost, zinc base plated sheets or coils occupy a position rather midway between plated steel and, for example, plated copper. Plated zinc is easily worked and thus is adaptable to blanking, forming, stamping and other fabrication methods.

Durability of pre-plated zinc is high. As a base metal it is rust-proof and highly corrosion resistant. With zinc as a base metal for platings, the raw edges or unplated metal back is no objection. The finish is beautiful, mirrorlike, and plated zinc is available in a range of gauges and tempers.

Zinc as a base metal may be procured with finishes of either nickel, chromium, copper or brass. It is available in sheets or long continuous coils, plated one or two sides, bright or satin finish. It is also available in crimps and patterns for unusual effects.





Just a few of the hundreds of items manufactured in quantities which employ pre-plated zinc base Nickeloid Metals.

While many metals are short in supply or delivered on an allocation basis thus necessitating anticipation of requirements, sheet or coil zinc is a little easier in supply. Our Peru, Illinois, plant, in addition, is located in the heart of the zinc rolling area where time is saved in delivery. In view of the workability and durable qualties of zinc base metal — it is one of the pre-finished Nickeloid Metals now receiving more than ordinary consideration on the part of manufacturers.

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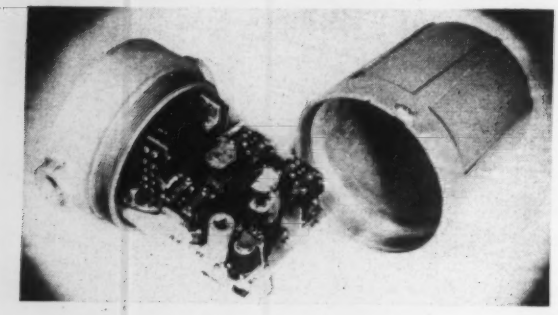
AMERICAN NICKELOID CO.

Peru 8, Illinois

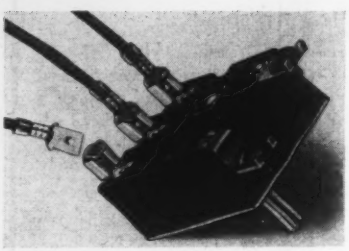
regulating the input feed. Variable time delays and a variable dead zone are incorporated to eliminate hunting and to insure operation at maximum output. Unit is made in one model, suitable for motors of all ratings. It employs two identical radio-type vacuum



tubes and operates from 115-volt, 60-cycle current. Housings available include standard sheet metal and explosion-proof types. Manufacturer: G. C. Wilson & Co., 2 N. Passaic Ave., Chatham, N. J.

For additional information circle MD 31 on Page 311

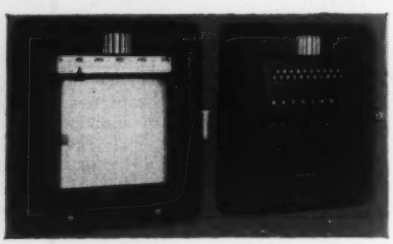
Plug-In Electrical Terminal



Quickness of assembly is the feature of the Ark-Les plug - in electrical terminal. Wires are crimped into neck of terminal blade in a simple operation. In use, blade is retained in its receptacle by spring pressure, low contact resistance being provided by flat construction with contact surface measuring ¼ by ⅜-inch. Female terminals can be supplied bent at any desired angle; both male and female terminals are available in brass, stainless steel or Monel. The assemblies meet Underwriters Laboratory test for listing at 20 amperes, 125-250 volts, ac. Ark-Les Switch Corp., 61 Water St., Watertown 72, Mass.

For additional information circle MD 32 on Page 311

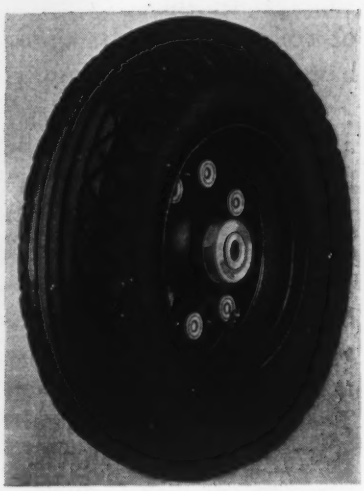
Temperature Recorder



Up to 160 separate thermocouple temperatures can be recorded at four-second intervals by new Speedomax temperature recorder. In usual operation the instrument simply indicates while numbered lights identify the couple temperature being measured at that moment. When the temperature reaches a preset limit the recorder starts its recording-chart drive and begins to record all points as a series of numbered dots; it also operates an alarm. Instrument can be set to record a single thermocouple, or groups of twenty as well as the total of 160. Equipment consists of two parts—a recorder and a switch assembly—each housed in a separate case. Manufacturer: Leeds & Northrup Co., 934 Stenton Ave., Philadelphia 44.

For additional information circle MD 33 on Page 311

Pneumatic Industrial Wheel



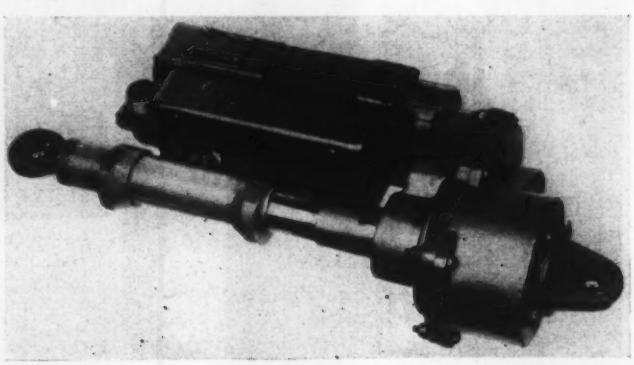
Type FDC industrial wheel is made to Tire and Rim Association standards and is equipped with high - capacity taper roller bearings and felt seal. It is constructed of high - tensile steel with full drop-center rim and utilizes a 4.00 by 8 (16-inch O.D.) pneumatic tire and separate tube. Holes through the ferrule rivets promote ventilation and air circulation, thus reducing road heat. Feature of unit is that tire can be removed without demounting wheel from axle. Manufacturer: Geneva Metal Wheel Co., 300 Railroad St., Geneva, O.

For additional information circle MD 34 on Page 311

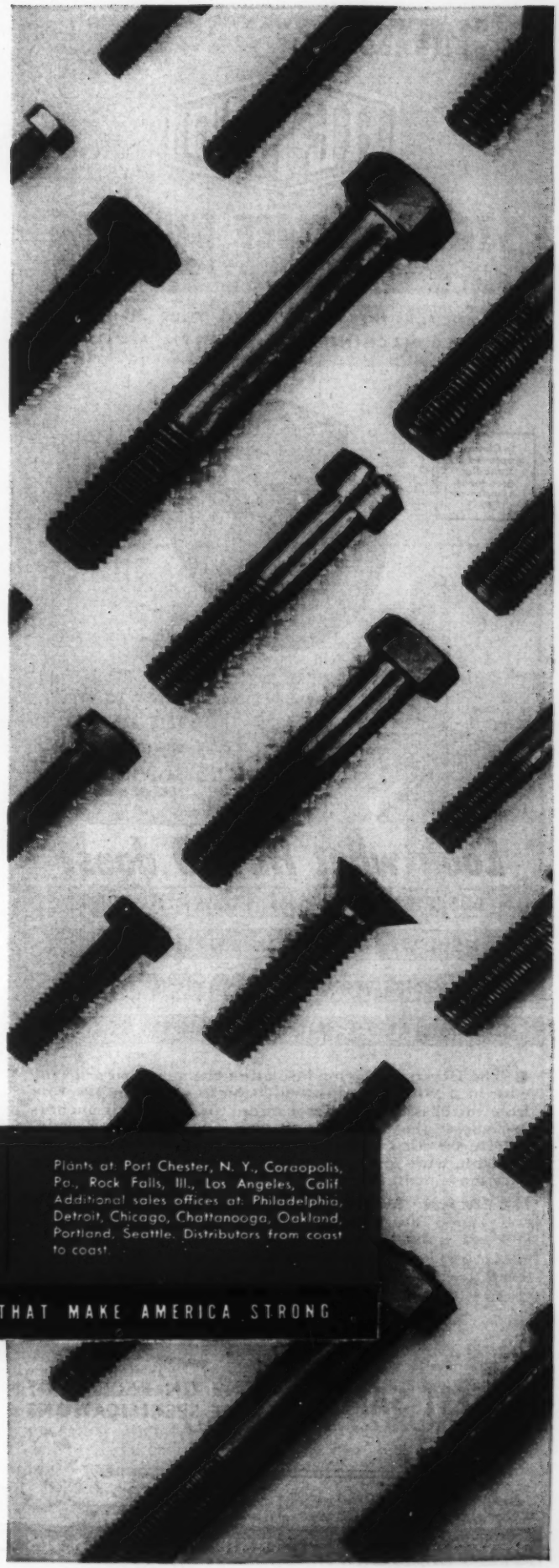
Electric Actuator

Powerful, compact, electric actuator weighs 12½ pounds and has a normal load rating of 7500 pounds. Assembly contains electric motor, magnetic clutch, locking brake, gear reduction unit, limit switches and adjustable limit-switch cams. Originally designed for aircraft use, the actuator has an ultimate load-to-weight ratio of 1250:1. Manufacturer: Hoover Electric Co., 2100 Stoner Ave., Los Angeles 25.

For additional information circle MD 35 on Page 311



Fastener appearance that contributes to the sales appeal of the final product—helps you get *True Fastener Economy*. The exceptionally fine finish of RB&W Cap Screws and Square Head Cup Point Set Screws is the product of more than a century of continuous research and progressive development in fastener manufacturing . . . backed by the skill of four generations of RB&W men and women.



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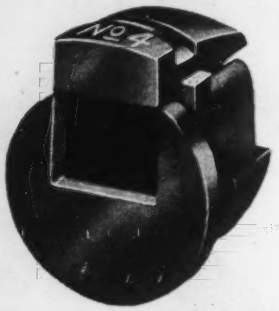
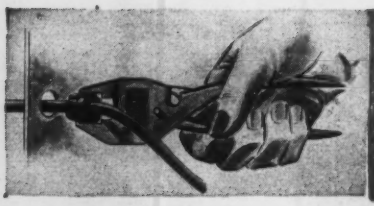




IT'S EASY TO APPLY THE HEYCO
1. Slip Heyco on wire
2. Snap Heyco into chassis hole

Look what HEYCO does!

1. ABSORBS CORD PULL, PUSH AND TORQUE
2. INSULATES WIRE FROM CHASSIS
3. PREVENTS WIRE FROM FRAYING
4. ELIMINATES TYING WIRE KNOTS

● The Heyco is a Nylon insulating grommet that grips the wire in a vise-like grip in addition to insulating the wire from the chassis. It does not injure the wire yet it anchors it firmly to the product, thus preventing strain on terminals. Heyco eliminates cord wear at chassis entrance and is available with spring extension for applications requiring wire movement. Illustrated Bulletin on request.

HEYMAN MANUFACTURING COMPANY
KENILWORTH 2, N. J.

And it improves Product Appearance at low cost!

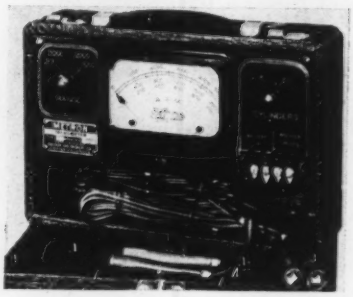
TEST SAMPLES SENT ON RECEIPT OF WIRE SPECIFICATIONS

HEYCO ELIMINATES STRAIN ON TERMINALS

engineering dept equipment

To obtain additional information on this new equipment see Page 311

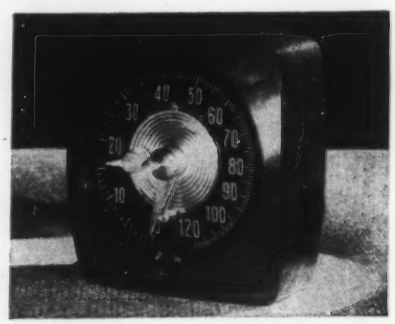
Breaker-Point Engine Tachometer



Designed particularly for use in testing gasoline engines, type 48U speed indicator requires no mechanical connection. It is used by tapping to the distributor breaker points, with power supplied by a standard wet-cell battery. Three ranges are incorporated into the instrument permitting readings from 100 to 5000 rpm; a two-position switch provides direct crank-shaft speed indication when either 6 or 8-cylinder engines are being tested. Accuracy is one per cent under usual temperature conditions. Manufacturer: Metron Instrument Co., 432 Lincoln St., Denver 9.

For additional information circle MD 36 on Page 311

Interval Timer

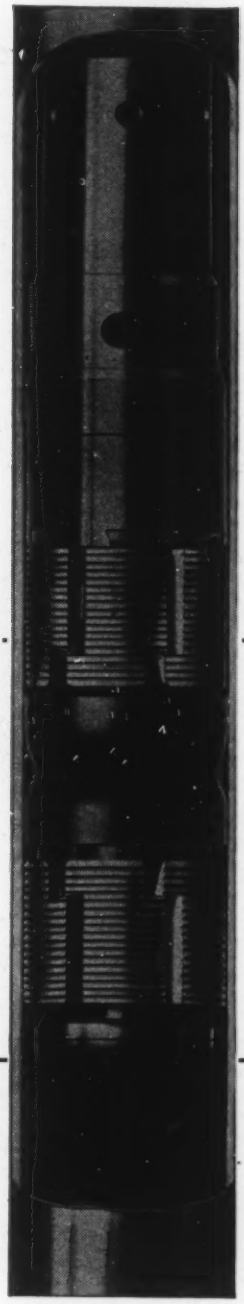


Type T-48 interval timers are made in four models to fit a variety of applications. Powered by synchronous, self-starting Telechron motors, the timers operate on 120-volt, 60-cycle power with a maximum load of 1200 watts. Three-way control knobs permit manual or automatic operation. Time intervals possible are: 0-120 seconds, 0-15 minutes, 0-2 hours, and 0-12 hours. Manufacturer: General Electric Co., Schenectady 5, N. Y.

For additional information circle MD 37 on Page 311

Continuous Photocopy Machine

High-speed continuous photocopying machine will make four hundred 8½ by 11 copies per hour. It is able to copy direct from originals up to 18 inches



Drillable Bridging Plug made by the Lane-Wells Company, Los Angeles, California, whose successful setting depends on the shear strength of two small pins of Revere Herculoy. These plugs vary from 38″ to 58″ in length.

These are the two small pins, made of Revere Herculoy to standard shear strengths, thus assuring proper setting of the Tripset plug. Pins are shown actual size.

Dependability protected through standardized-strength Herculoy

● Here is a case in which the successful operation of a large and somewhat complicated device depends upon one of its smallest and least expensive parts. The parts are two pins of Revere Herculoy. The device is a plug employed to seal off an oil well at any desired depth, to prevent taking oil or water from lower strata.

Proper setting of this plug within the well depends on those two small pins. They must shear at exactly the right load, imposed by a special setting tool. If the pins should shear too easily, the plug might not be securely set in the well and might fall to the bottom; if the pins were too tough, the plug might not set at all. From the material standpoint, successful operation of a device costing as much as $310.00 depends on the uniform shear strength of a few cents' worth of rod.

It was to assure that uniformity that the Revere Technical Advisory Service was called into action. Studies were made of the needs, tolerances specified, and means devised to assure meeting them. The specifications when finally drawn up were rather unusual, and their fulfillment is another demonstration of Revere's ability to turn out special orders when absolutely necessary. Incidentally, Lane-Wells Company, maker of the Drillable Bridging Plug, also uses Revere phosphor bronze, strip brass, Herculoy rod and free-cutting brass rod for other parts.

Before you place your next order for copper and copper alloys, get in touch with the nearest Revere office. And remember, if you are having any difficulties in the employment of copper and brass mill products, the Revere Technical Advisory Service will gladly collaborate with you.

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COPPER AND BRASS INCORPORATED

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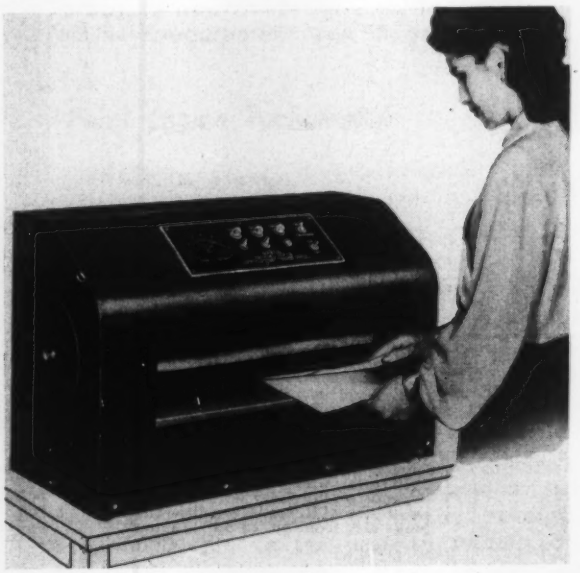
engineering dept equipment

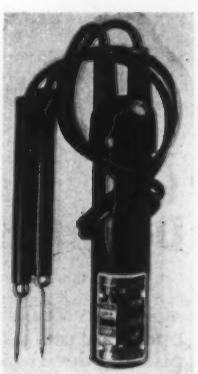
wide in any length. The new machine, called the CP-18 Apeco Continuous Copier, copies direct from an original at full scale and requires no masters or stencils. In operation an original and a piece of photocopy paper are fed together into the machine. A continuous canvas belt and revolving glass cylinder



keep them under constant pressure, preventing slipping. Manufacturer: American Photocopy Co., 2849 N. Clark St., Chicago.

For additional information circle MD 38 on Page 311

Voltage Tester



Voltage test units, made in two models, cover high-frequency and low-voltage requirements. The high-frequency tester is suitable for use on voltages from 110 to 550 at 400 cycles and may also be used on dc from 30 to 120 volts. The low-voltage tester is designed for use with ac voltages from 12 to 60 at 60 cycles and dc voltages from 10 to 40. Bodies of the testers are of one-piece fiber construction, leads are protected by one-piece rubber insulation. Sharp "spear" points are provided on probes to permit piercing of conductor insulation. Manufacturer: Square D Co., 6060 Rivard St., Detroit 11.

For additional information circle MD 39 on Page 311

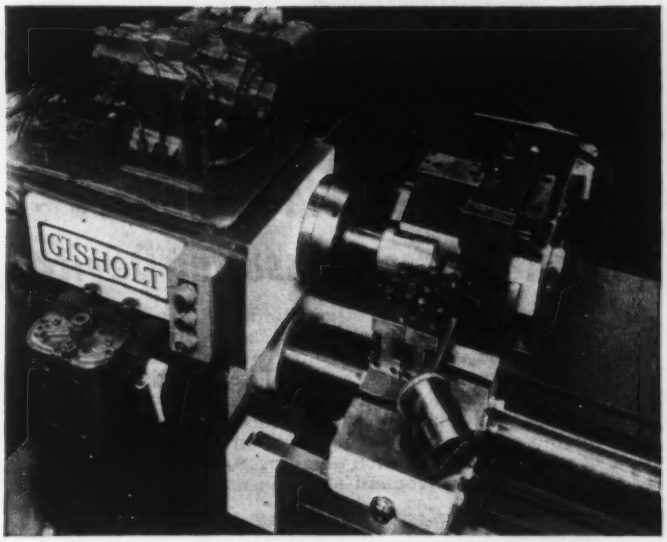
Direct-Reading Tachometer

Direct-reading circular-dial tachometer known as the O-Z Tachoscope indicates both rpm and fpm. Timing is automatic, no stop watch being required. The instrument is made in two types: Type A requires 3 seconds for operation and has a speed range

HOW TO DOUBLE PRODUCTION ON AN AUTOMATIC LATHE

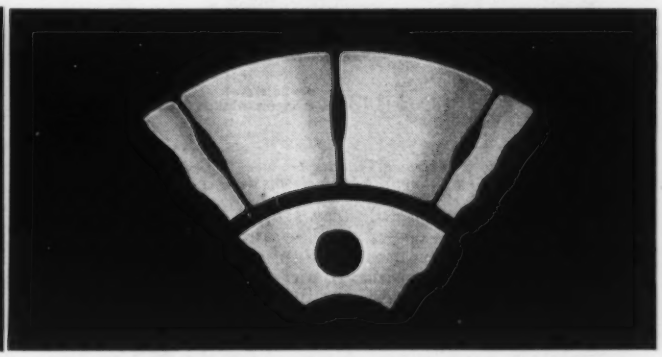
...give it a Brake*!

*** And the Brake to give it is a WARNER ELECTRIC INDUSTRIAL CLUTCH-BRAKE**

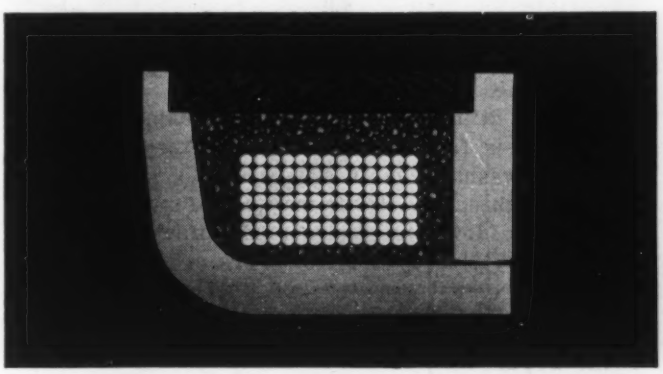


HERE'S HOW Gisholt does it on their No. 12 Hydraulic Automatic. Job: face, turn and cut off the riser on cast aluminum pistons. All starting and stopping of spindle is done by Warner Electric Clutch and Brake Units. Main drive motor is constantly running. Result: faster cycle operation — production doubled from 4 to 8 pieces per minute.

THE WARNER ELECTRIC INDUSTRIAL CLUTCH-BRAKE as mounted on a Gisholt No. 12 Hydraulic Automatic lathe. Note simple, compact mounting arrangement. Both units have only two parts. Ready accessibility of all clutch-brake parts means quick, easy maintenance however seldom required.



ARMATURE SECTION: One of only two parts for either Clutch or Brake units. Consists of magnetic segments welded to steel back-plate (see cut). Especially designed for high heat dissipation. Heat has no effect on unit efficiency because segment expansion is always linear . . . keeps full magnet contact at all times.



MAGNET SECTION: The other of the two parts for either Clutch or Brake units. Consists of electro-magnet faced with long-wearing, high friction material. Power, applied through coils imbedded below (see cut), applies friction *plus* magnetic attraction for fast, super-powerful clutch or brake action.

● Warner ICB Units* are low-cost key to more automatic, safer operation of wide variety of motors and machinery . . . give you infinite control of degree of clutch or brake action. For details or engineering assistance write: INDUSTRIAL DIVISION, WARNER ELECTRIC BRAKE MFG. CO., Beloit, Wis.

WARNER
ICB UNITS

***ICB Unit — The trade designation for the Warner Electric INDUSTRIAL CLUTCH OR BRAKE UNIT.**

DC SILICONES

Silicone News

DC Silicone Fluid Stabilizes Versatile Force Measuring Device

Thrust, torque and other kinds of force are measured by air in a device so sensitive and versatile that the same unit can measure the thrust of a 2000 h.p. engine while responding to the weight of a coin. It is used in the cradle dynamometer measurement of aircraft and automobile engines, the testing of piston rings and axles and automatic batch weighing. And it operates without any movement of the measured system.

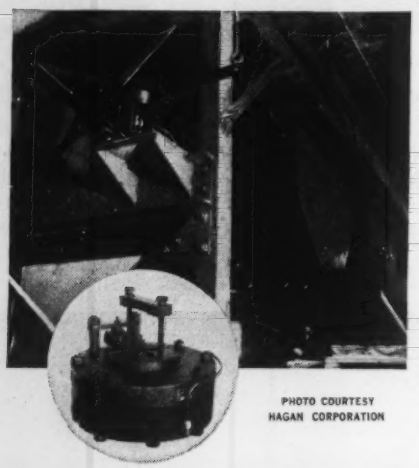


PHOTO COURTESY
HAGAN CORPORATION

Accuracy of air operated, null displacement "ThrusTorq" is stabilized by VC 200 Fluid in viscous damper.

The "ThrusTorq" made by Hagan Corporation of Pittsburgh is essentially an air chamber, one side of which is a flexible diaphragm. A poppet valve admits compressed air until pressure in the air chamber exactly balances the force exerted on the diaphragm by the torque arm. When the force is reduced, air is exhausted to maintain equilibrium. Air pressure required to balance the force is registered by a manometer, or gauge calibrated in foot-pounds.

But the stability of a system for balancing inertial forces depends upon adequate damping. That is done most effectively by DC 200 Silicone Fluids in a viscous damper consisting of two diaphragm chambers connected by a small orifice in the partition plate.

Critical damping and more compact hydraulic systems both depend upon the remarkably low rate of viscosity change in DC 200 Fluids over a wide temperature range. For more information about these silicone fluids including data on resistance to oxidation and to mechanical shearing, lubricity, water repellency and dielectric properties, phone our nearest branch office or write for booklet C13 B2.

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FIRST IN SILICONES

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of 0-20,000 rpm and 0-10,000 fpm; type B requires 6 seconds for operation and has a speed range of 0-2000 rpm and 0-1000 fpm. Both types can be used in measuring right and left-hand speeds to an accuracy of 0.5 per cent. Manufacturer: O. Zernickow Co., 15 Park Row, New York 7.

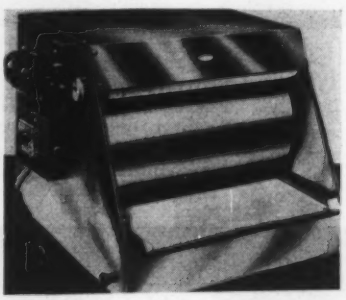
For additional information circle MD 40 on Page 311

Pocket-Sized Circuit Tester

Wide-range circuit tester, series 40, can be used for measuring resistance as well as either ac or dc current and voltage. In addition it has 6 decibel ranges from −22 to +70 db. The ac-dc and output voltage ranges are 0 to 3, 12, 60, 300, 1200 and 6000 volts; all at 1000 ohms per volt. The dc current ranges are 0 to 0.6, 6, 60 and 600 ma while the resistance ranges are 0 to 0.05, 0.5, and 5 megohms. Instrument is entirely selfcontained and measures 3¾ by 6¼ by 2½ inches. Use of rotary range selection permits two jack pins to serve all standard functions; a recessed safety jack being used for the 6000-volt circuit. All multiplier and shunt resistors are accurate to one per cent. Manufacturer: Precision Apparatus Co., 92-27 Horace Harding Blvd., Elmhurst, Long Island, N. Y.

For additional information circle MD 41 on Page 311

Electric Print Drier



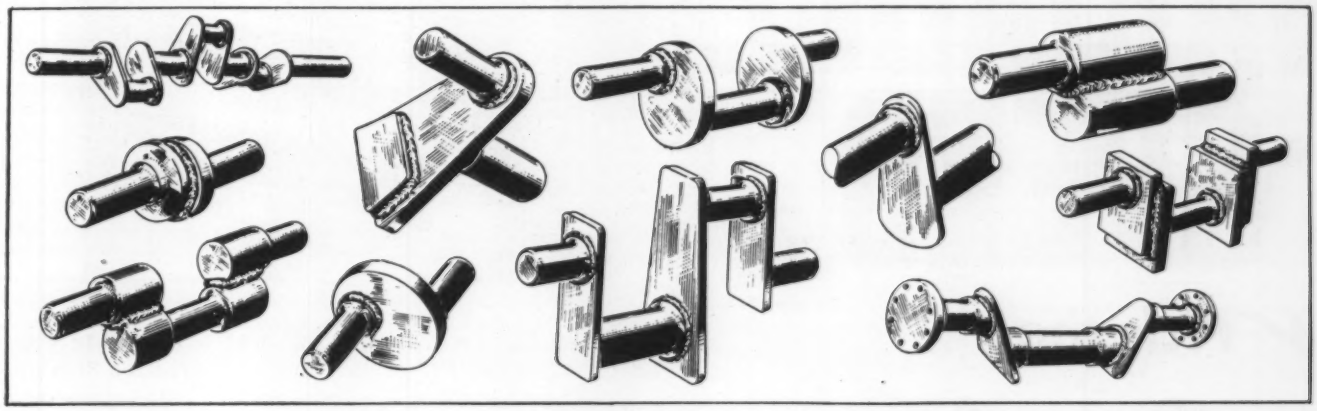
Drum drier measuring 18 by 18 inches will dry photographic prints, photostats and blueprints. Its capacity is up to forty 11 by 14 prints an hour. The unit draws 350 watts operating on 120-volt ac or dc power and utilizes a heavy-duty, variable-speed, fan-cooled motor for driving. The drier has a replaceable and washable cloth belt which is self aligning and self tightening. Prints may be fed onto the apron face up or down as desired. Manufacturer: Fedco Products, 37 Murray St., New York.

For additional information circle MD 42 on Page 311

Print Dryer

Rotary dryer, tradenamed Lott Rotomaster, can be used for drying photographs, photocopies, blue prints and similar reproductions. It dries both glossy and matte finished prints. Features include built-in squeegee, mirror-finish stainless-steel drum, adjust-

How Stronger Cranks Are Built at Lower Cost with Arc Welding



Examples of cranks and crankshafts fabricated from steel at lower cost with arc welding.

Many machinery parts like these simple cranks are being fabricated from standard steel shapes, eliminating the need for forgings or castings. Shaft components for the cranks may be produced from bar stock, machined to form as simple lathe operations, and throw members flame-cut from steel plate. Component parts are tack welded first or are located in simple fixtures for welded assembly using electrodes suited to the type of steel used.

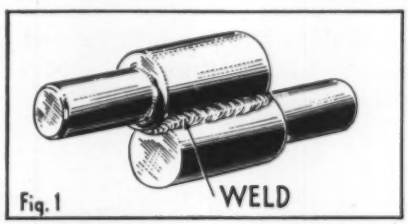


Fig. 1

Simplest of all cranks is shown in Fig. 1. Where accuracy of throw is unimportant, bars having a diameter equal to the throw can be fillet welded. If a longer crank throw must be maintained, the shafts can be fillet welded to a disc (Fig. 2) or two studs machined as shown in the lower sketch (Fig. 2) can be positioned back to back and the flanges fillet welded.

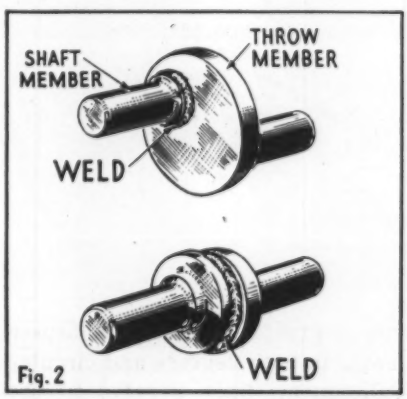


Fig. 2

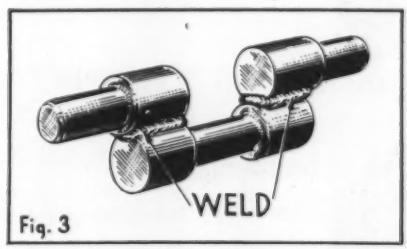


Fig. 3

Fig. 3 shows the elements of a single-throw crankshaft. On applications where the throw of the crank exceeds the diameter of the shaft members, discs cut from bar stock or flame-cut from steel plate are incorporated (Fig. 4).

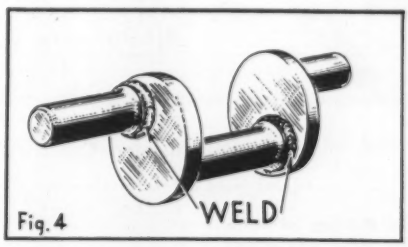


Fig. 4

To simplify the welded assembly of a crankshaft, the throw members can be built from rectangular stock and fillet welded as shown in Fig. 5, after which a trim cut may be taken on a lathe for appearance or balance.

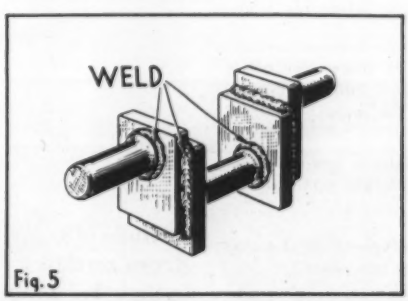


Fig. 5

Multiple throw crankshafts, as illustrated in Fig. 6, can be weld-fabricated to suit any requirements of size and throw. If necessary, different alloys can be incorporated in various component members to best suit the needs of the crankshaft. After welded assembly, the crankshaft can be

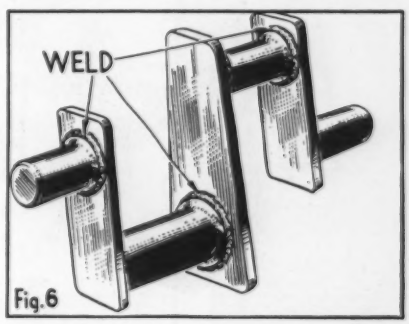


Fig. 6

machined all over in the conventional manner, accurately holding any size and throw specified.

Counterbalancing is easily accomplished by fillet welding weights to throw members as indicated in Fig. 7. Small deposits of weld metal can be added to any part of the crankshaft if unusually accurate balancing must be attained.

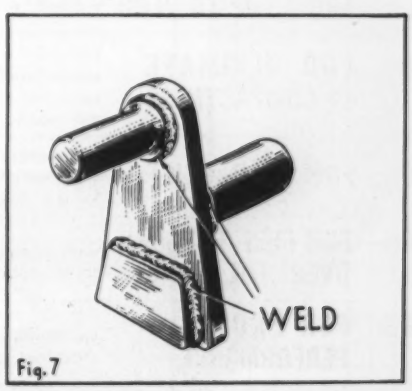


Fig. 7

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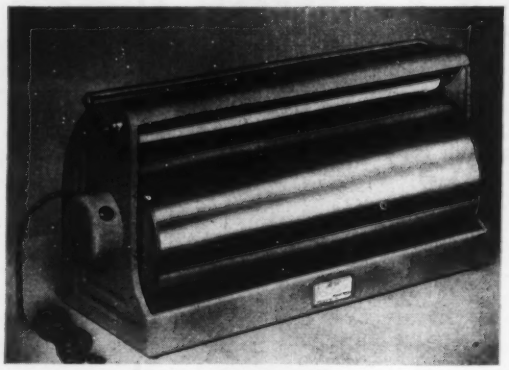
2nd	FOR EVERY SPEED FROM TOP TO ZERO	in infinite steps, plus reverse where wanted, without stopping the motor.
3rd	FOR ULTIMATE IN COMPACTNESS	the only variable drive built as a streamlined extension of a standard induction motor, or available without motor.
4th	FOR DEAD QUIET	responsible for its choice for office machinery where the sound level must be the same as the motor.
5th	FOR FULL TORQUE OVER THE RANGE	with doubled torque at low speeds—an essential for many applications.
6th	FOR PROVEN PERFORMANCE	as standard equipment on leading machines for over ten years.

Send for Bulletin 511. No obligation.

GRAHAM TRANSMISSIONS INC. 3754 N. HOLTON STREET MILWAUKEE 12, WIS.

engineering dept equipment



able curtain tension, and two-heat temperature control. Case is of all-welded steel construction finished in an attractive blue-gray wrinkle. Manufacturer: Lott Mfg. Co., Jamestown, N. Y.

For additional information circle MD 43 on Page 311

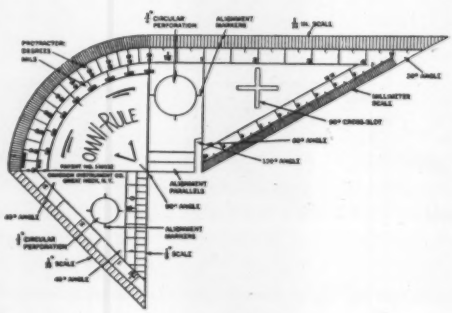
Photocopy Papers

Two new papers for photocopying have been added to the Kodograph line. Ledger-Duplitized contact paper is now coated on both sides of the sheet permitting prints to be made on both sides for record purpose in permanent binders. Kodagraph projection paper, formerly only available in extra thin and ledger weights, is now made in standard-weight stock. Manufacturer: Eastman Kodak Co., Rochester 4, N. Y.

For additional information circle MD 44 on Page 311

All-Purpose Scale

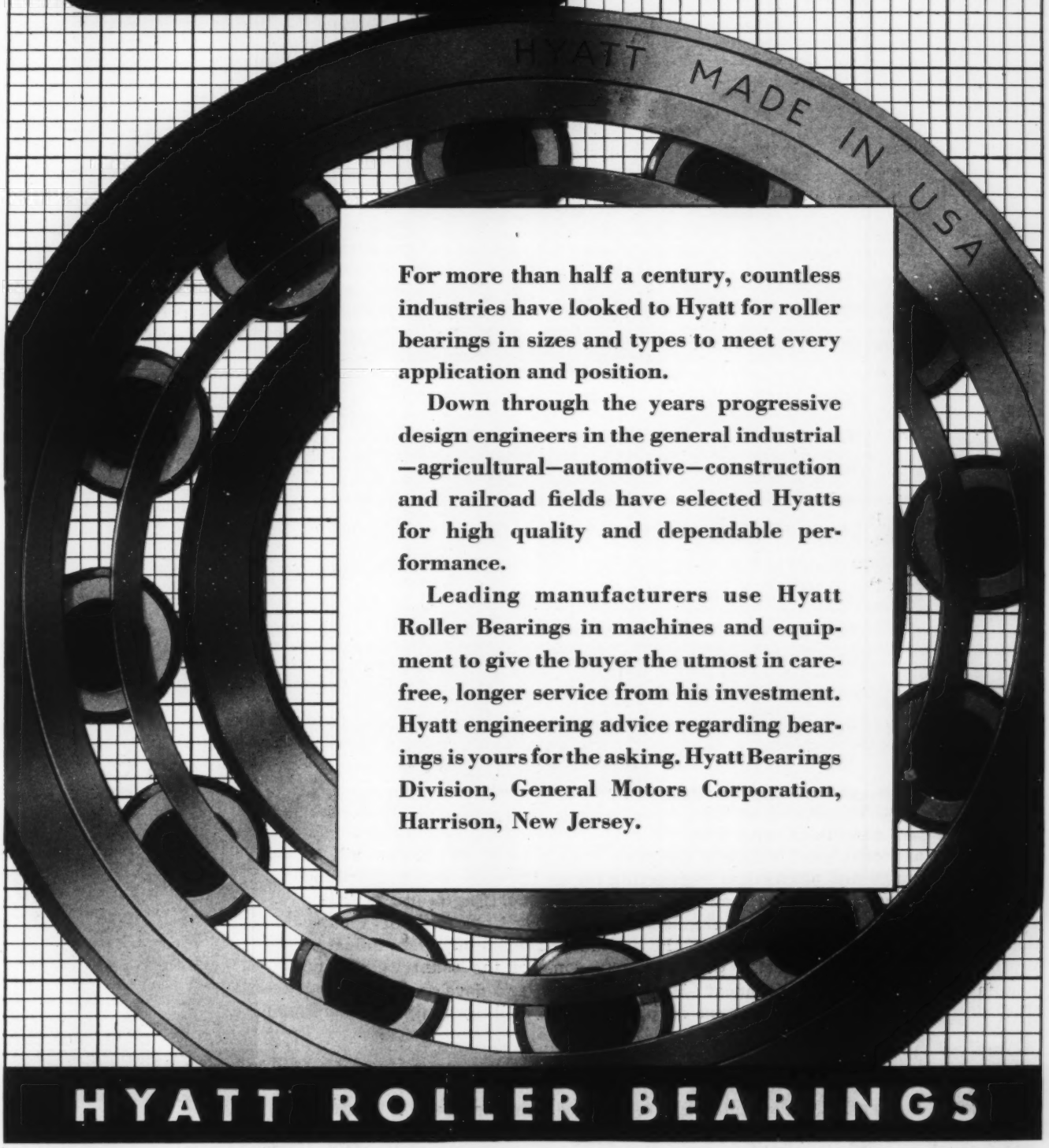
Drafting instrument combining protractor, triangles, scale, template and straight edge is tradenamed Omni-Rule. The device is made of 0.040-inch vinyl plastic with printing on the upper surface to reduce wear. Triangles contained in the instrument



include 30, 45 and 60 degree; protractor measures from zero to a right angle in both degrees and circular mils. To facilitate alignment, lines parallel to the straight edges are provided. Manufacturer: Omicron Instrument Co., 42 Soundview Drive, Great Neck, N. Y.

For additional information circle MD 45 on Page 311

There were no Roller Bearings before Hyatt made them



For more than half a century, countless industries have looked to Hyatt for roller bearings in sizes and types to meet every application and position.

Down through the years progressive design engineers in the general industrial—agricultural—automotive—construction and railroad fields have selected Hyatts for high quality and dependable performance.

Leading manufacturers use Hyatt Roller Bearings in machines and equipment to give the buyer the utmost in carefree, longer service from his investment. Hyatt engineering advice regarding bearings is yours for the asking. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

Men OF MACHINES

F. R. BENEDICT has been made manager of the headquarters engineering departments of the Westinghouse Electric Corp. and will be responsible for the operations of the industry engineering, foreign engineering, engineering laboratories, and standards departments. Mr. Benedict joined the Westinghouse staff ing 1928, serving five years as laboratory engineer in the high-voltage laboratory at Trafford, Pa. From 1934 to 1936 he was engaged in special studies on insulating materials and for the next two years was engineer in charge of the Trafford Laboratory. In 1938 he was made liaison engineer, in which capacity he handled the co-ordination of problems involving the procurement and application of engineering materials. He was transferred to the district engineering and service department in 1940 and a year later was appointed manager of engineering and service in the New England district. He became manager of the product analysis section in February, 1944, serving in that capacity until becoming manager of the industry engineering department in 1945.

F. R. Benedict

Walter Brown

WALTER BROWN has been appointed chief engineer of The Brewster Co., Shreveport, La. Associated with the company as assistant chief engineer for more than a year, Mr. Brown will be in charge of design and mechanical engineering for all Brewster matched drilling equipment. A member of the American Society of Tool Engineers, he holds a master's degree in mechanical engineering from the University of Vienna. During his twenty years experience in the oil and petroleum suppliers industry, Mr. Brown has held engineering positions with some of the country's leading manufacturers of drilling equipment. He has invented and developed a number of devices now extensively featured in pipeline and drilling equipment.

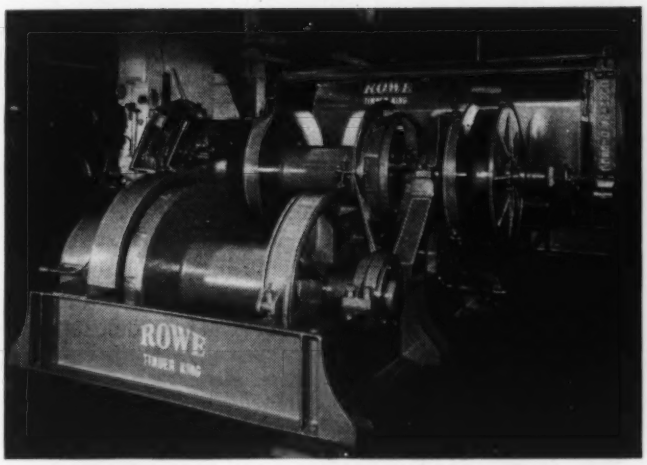
BARRON D. BERGER has recently been appointed chief engineer of National Electric Welding Machines Co., Bay City, Mich. He was formerly assistant chief engineer in charge of special machine design at Federal Machine and Welder Co. of Warren, Ohio, and also served as engineering assistant to the vice president and general manager of the welding division of that company. Mr. Berger graduated from Columbia University School of Engineering where he earned degrees of A.B., B.S., and M.S. in mechanical enginering. He has served as chairman and committee member on various Resistance Welder Manufacturer's Association technical committees, and brings to his new position wide experience in the resistance welding field.

LEO P. GAJDA has been promoted from the position of chief draftsman to director of engineering of Snyder Tool and Engineering Co., Detroit. He succeeds GEORGE D. MELLING who held the position since 1946 and who leaves Snyder to form his own company in partnership with Howard McCoy.

R. C. SEBOLD has been named director of engineering for Consolidated Vultee Aircraft Corp., San Diego,

Barron D. Berger

Torrington Spherical Roller Bearings Stand Up to Shock and Deflection In Rowe Timber King Yarders



For handling heavy materials like logs, beams and pipe, Timber King Yarders have to be rugged. To back up a 32-ton line pull, and make sure each Yarder will stand up to hard usage and severe shock, Rowe Machine Works uses 6 Torrington Spherical Roller Bearings on main, haulback and strawline drums.

These precision bearings give the low torque that means easy starting under heavy loads, smooth running with low power consumption. When shock loads deflect drum shafts or distort yarder frames, Spherical Roller Bearings compensate automatically for misalignment, keep rolling effortlessly.

Easy handling and installation of Spherical Roller Bearings, due to their unit design, is appreciated both in assembly and servicing. Readily accessible, the bearings, reduce down time in the field. Were it necessary, two men could easily dismount and remount all six bearings in a day.

Welded construction of yarder frames would make it difficult to secure accurate alignment with rigid bearings. Spherical Roller Bearings make proper initial and running alignment a matter of course. Time is saved in assembly. Long service life is assured under the most severe operating conditions.

In equipment you build or operate, specify Torrington Spherical Roller Bearings for long service life and minimum maintenance attention. Our engineers offer their experience to help you with your friction problems. Write us today. THE TORRINGTON COMPANY, South Bend 21, Ind. or Torrington, Conn. District offices and distributors in principal cities.

TORRINGTON SPHERICAL ROLLER **BEARINGS**

Spherical Roller • Tapered Roller • Straight Roller

Needle • Ball • Needle Rollers

The best hose you can buy is usually the cheapest in the long run. For a top grade hose stands up. It keeps fluid or gas flow under complete control despite constant flexing, vibration, pulsating loads. Such a hose offers greater security against costly replacements, circuit troubles, customer complaints. No wonder so many well-known manufacturers today rely on Resistoflex assemblies!

Four Resistoflex lines, for example, are used in the lubrication circuit of the smoothly operating Reeves Variable Speed Transmission. Even where temperature extremes are encountered, these lines have proved they'll *stay* flexible, and withstand a tremendous amount of flexing.

Why not play safe with Resistoflex quality in your own applications? "Line up" with these long-lasting, leakproof assemblies that are impervious to hydraulic fluids, oils, gases. Write for details.

Lubrication system of the Reeves enclosed design Variable Speed Transmission with its four Resistoflex assemblies.

Trade Mark Reg. in U. S. & Can. Pat. Off.

RESISTOFLEX

CORPORATION

Belleville 9, New Jersey

FLEXIBLE HYDRAULIC, OIL, GAS, VACUUM AND REFRIGERANT LINES • COUPLINGS AND FITTINGS

Calif. Mr. Sebold, who has been with Convair 19 years, was formerly chief engineer of the Fort Worth division. He will be succeeded in that position by J. W. LARSON.

♦

EDWARD J. HRDLICKA was recently elected vice president of Hydraulic Equipment Co., Cleveland. Mr. Hrdlicka, associated with the company over twelve years, has served as chief engineer and vice president in charge of engineering and assumes the post vacated by HAROLD J. ZIMMERMAN who has resigned to re-enter the field of industrial engineering.

♦

GEORGE E. HUDSON has been appointed professor of physics at New York University College of Engineering where he has been connected with research involving fundamental physical problems related to the field of jet propulsion. Dr. Hudson served the university as associate technical director and later as technical director, a post he currently holds and will continue to fill.

♦

A. E. GIBSON, president of Wellman Engineering Co., Cleveland, has been re-elected vice president of the Associated Industries.

♦

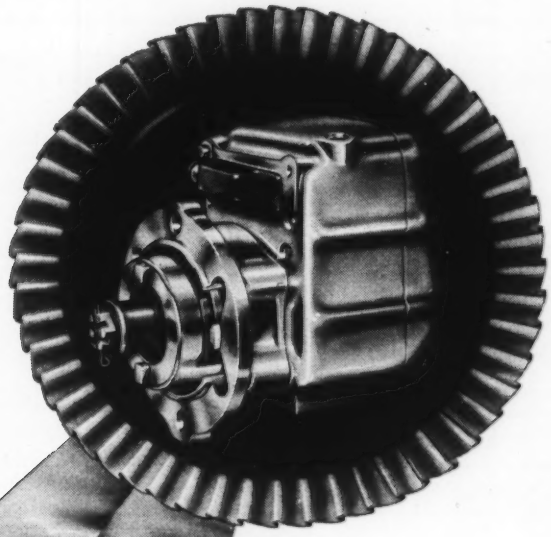
MAURICE HOLLAND, industrial research consultant, has been elected to the staff of Southwest Research Institute. Mr. Holland was director of the division of engineering and industrial research for the National Research Council, a consultant to the Third World Power Conference, and Council delegate to the World Power Conference at London, Pan-Pacific Science Congress at Tokyo, and the Science Management Congress at Prague.

♦

E. T. RAGSDALE has recently been named general manufacturing manager of Buick Motor Division, Flint, Mich. to succeed O. W. YOUNG. HARRY C. DOANE and RICHARD C. COOK have become assistant chief engineers. Mr. Doane will be in charge of the design divisions, production engineering and the drafting divisions. Mr. Cook will have charge of experimental manufacturing, experimental test, and special projects.

♦

BRUCE L. WILSON has been named chief of the engineering mechanics section of the National Bureau of Standards, Washington, D. C. In this capacity he will direct research on structural elements and metal structures, and will also conduct research on special apparatus and methods for measuring forces, deformations, and hardness. Mr. Wilson has been in charge of experimental research to determine fatigue strength of screw threads of various thread forms for studies being made by the National Bureau of Standards in cooperation with the British National Physical Laboratory and the Canadian National Research Council. Born in Graham, Wash., Mr. Wilson received his bachelor's degree from Reed College,



Another First

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A Prime Factor in the New Bell Prime Mover

When Bell Aircraft Corporation gave the first really modern touch to the old-fashioned wheelbarrow, they made sure the ignition equipment was also the most modern by specifying a Bendix-Scintilla* H-Type Magneto. The performance of this magneto makes it the logical choice to meet the exacting requirements of this versatile Prime Mover.

For dependable, economical performance on the toughest jobs, you can't beat the Bendix-Scintilla H Magneto. To step up performance on your single cylinder engines, get full specifications on the Bendix-Scintilla H Magneto.

*TRADEMARK

Combining the functions and features of a giant wheelbarrow, a sturdy platform carrier, and a light scraper and grader, the new Bell Prime Mover has a capacity of 1000 pounds and an ability to climb 20% grades fully loaded.

OUTSTANDING FEATURES YOU'VE ASKED FOR

Waterproof coil • Waterproof, high-tension outlet Higher voltage at starting speeds • Constant spark over entire speed range • Equipped with impulse coupling Compact and sturdy construction.

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Oreg. in 1929. Immediately thereafter he joined the staff of the National Bureau of Standards, working in the enginering mechanics laboratory. He is a member of the American Society for Testing Materials, the Washington Academy of Sciences, and the Philosophical Society of Washington.

♦

FRANK T. SISCO has been appointed technical director of the Engineering Foundation, New York. He served seven years as chief of the metallurgical laboratory of the U. S. Army Air Corps at Wright Field, Dayton, Ohio, and was made director of alloys of iron research in 1930.

♦

C. RICHARD WALLER has been named vice president and director of engineering of the De Laval Steam Turbine Co., Trenton, N. J. H. G. BAUER has been elected vice president and executive engineer.

♦

G. W. MERREFIELD was recently appointed consulting engineer to the foundry industry by Giffels & Vallet Inc. of Detroit. Mr. Merrefield has over 30 years experience in foundry operation and design and has served similar positions with U. S. Steel, Clark Equipment, American Radiator Co., Chicago Hardware Foundry and others.

♦

DUFFER B. CRAWFORD, gas research engineer, has been named to the staff of Southwest Research Institute. Mr. Crawford developed the Elliott oxygen plant cycle and has done research work in low-temperature properties of air and its components.

♦

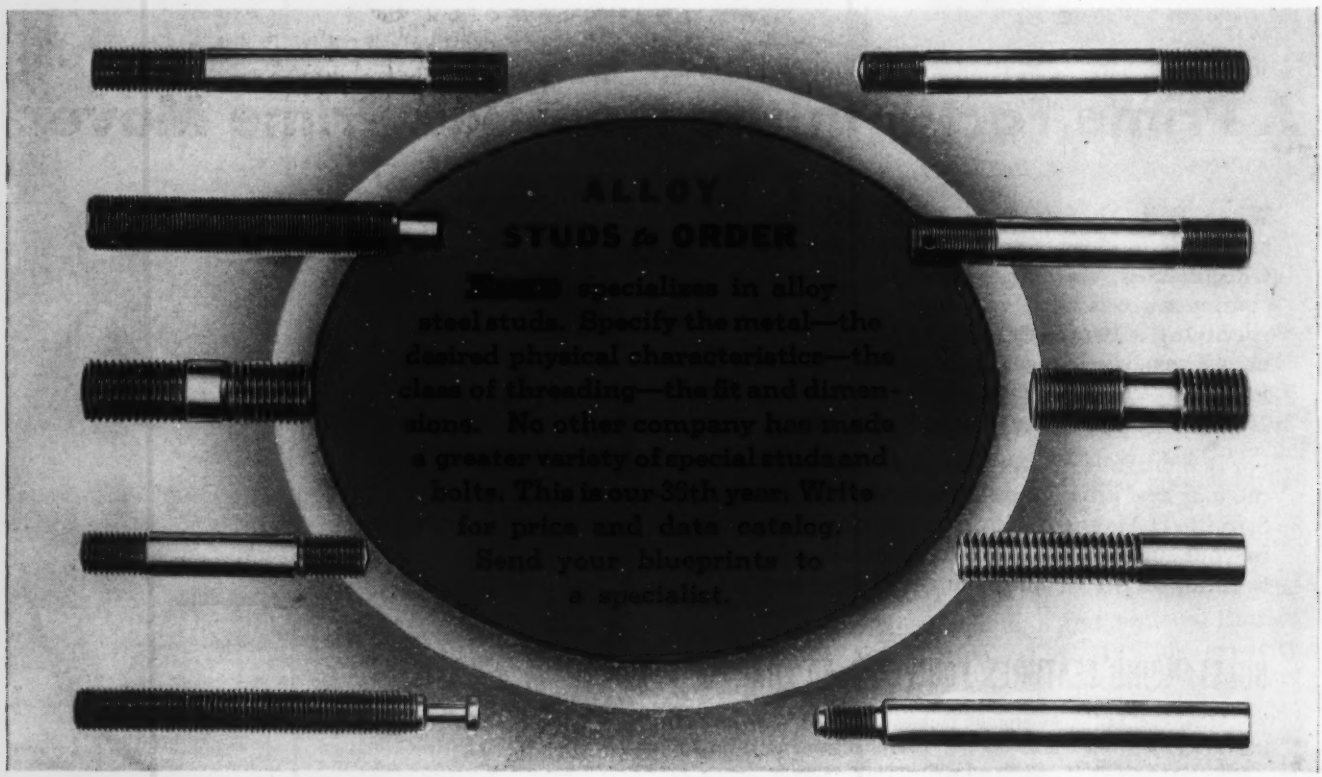
JOHN J. MEADOWS has been made supervisor of the reorganized mechanical engineering department of Sam Tour & Co., Inc., New York. Mr. Meadows has had thirty years experience in mechanical and electrical engineering. He served on the staff of the Otis Elevator Co., nine years with the Board of Transportation, and four years in the engineering department of the New York Central Railroad. For the past five years he has been engaged in consulting work. Mr. Meadows has written numerous articles for technical journals and holds several patents for devices used by the Army and Navy.

♦

C. H. BENBROOK has been appointed director of research and development of the Ozalid Division of General Aniline & Film Corp., Easton, Pa.

♦

B. R. TEREE has been appointed director of engineering, hydraulic division of the New York Air Brake Co. He has been associated with the Curtiss Wright Corp. as assistant chief of the structures department in Buffalo, and from 1946 to February 1949 was project engineer in charge of aircraft development, laboratory director and engineering manager with the Weatherhead Co., Cleveland.



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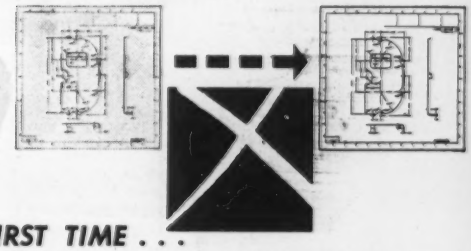
you can print a photographic intermediate in your direct process or blueprint machine . . . and develop it in standard photographic solutions. Kodagraph Autopositive Paper brings you this advantage in the reproduction of any drawing or record—whether it be translucent or opaque . . . old or new.



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you can produce positive photographic intermediates directly from your originals—without a wasteful negative step. The result every time is a print with dense black photographic lines on a clear, non-curling translucent base—an intermediate that produces uniform prints at practical machine speeds . . . that's "photo-lasting" in the files.

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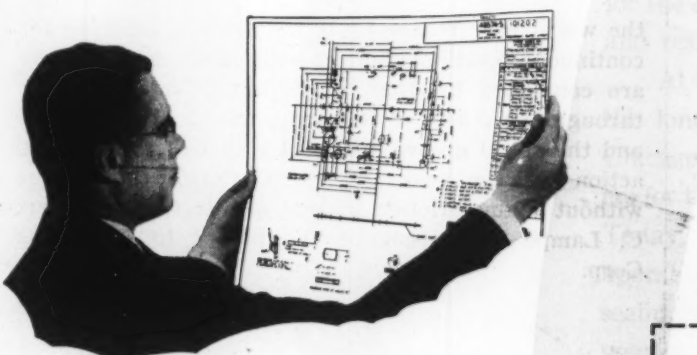

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you can handle a photographic intermediate material in ordinary room-light—dispense with the darkroom! And processing is simplified still further because Kodagraph Autopositive Paper has wide latitude . . . is amazingly uniform from sheet to sheet, package to package.

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Please send me a copy of "The Big New Plus" —your booklet about Kodagraph Autopositive Paper, and the other papers in this new Kodak line. I have
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Kodak

Cambridge WIRE BELTS

combine processing and movement with

SPEED

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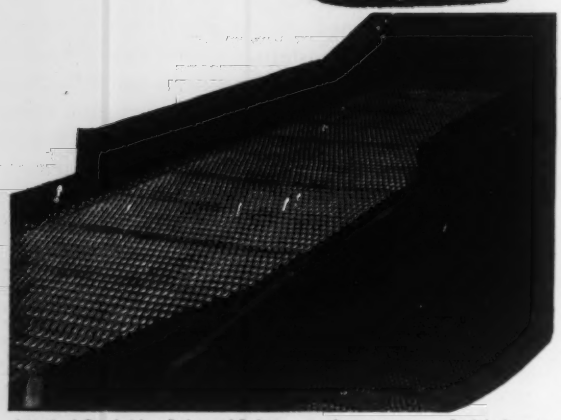
DURABILITY



A typical Cambridge Balanced Belt on a package conveyor. Such belts can speedily and economically handle all types of packages, products or raw materials. Dirt and dust sift through open mesh for extra cleanliness.

Whether your products are treated with heat, cold or corrosive agents, you can get a faster, more economical output by combining processing with product movement on a Cambridge woven wire conveyor belt.

SPEED—because the moving belt permits *continuous* treatment, ends time-wasting machine stops.

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Call in your Cambridge Field Engineer whenever you have a problem combining movement with processing.

FREE! 130 pages of illustrated data on Cambridge belts. Gives design, application, installation data. Write today on your letterhead.

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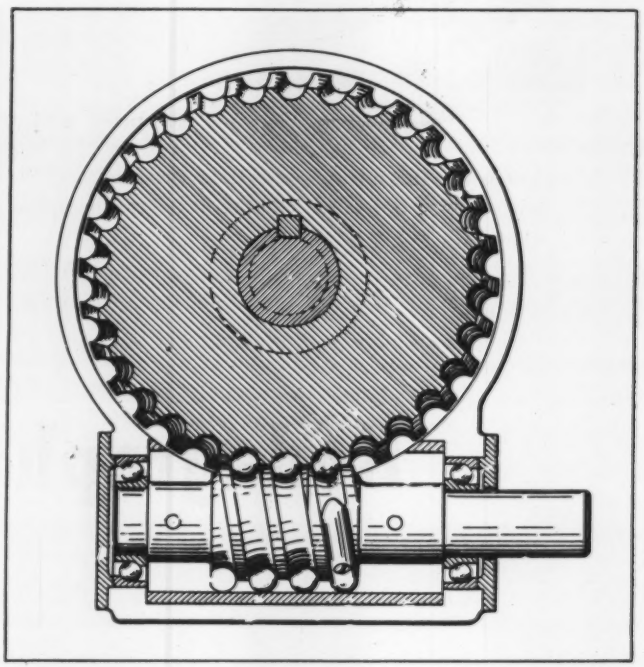
Noteworthy Patents

INCREASED WORM GEAR EFFICIENCY resulting from elimination of all sliding friction is accomplished with the ball bearing worm gear design covered in patent 2,451,998. Instead of teeth, the worm gear has semicircular recesses matching a spiral groove in the worm. This groove has a lead equal to the spacing of



the worm gear recesses. If the drive is intended for continuous rotation, opposite ends of the spiral groove are connected together by a passageway extending through the center of the worm shaft. This passage and the spiral groove are filled with balls, the rolling action between gear and worm transmitting torque without sliding friction. Eric C. Wahlberg and Robert C. Lampe have assigned the patent to Electrolux Corp.

SELF-CONTROLLED CLUTCH, containing a pressure pump and hydraulic circuit in a single unit in addition to the usual friction shoes, is covered in patent 2,449,717 granted to C. A. Robertson. A cam mounted on the driving shaft operates a reciprocating piston type pump through a cam roller and piston rod. Hydraulic fluid from this pump passes through a two-way control valve and into a double-acting piston which moves the brake shoes radially outward and into contact with the brake drum through a fork and collar arrangement. As long as there is any relative movement between the brake drum and driving shaft, the pump will be actuated;

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That's because Sirvene means something different in every application. Primarily it is a specially compounded elastomer designed to meet a critical operational requirement. No two uses of Sirvene are alike. Every purpose, every design and every formula is individual. You, the design engineer, determine the need and type, and Sirvene engineers work with you in developing the particular part required for the efficient operation of your mechanism. The physical properties and resistance qualities are custom developed to do just *your* job.

At the same time, the name Sirvene automatically implies one of the longest experiences in elastomer development in this country. Chicago Rawhide was one of the first to pioneer in combining elastomers for the purpose of producing specified qualities and characteristics. Today, many outstanding leaders in all branches of industry depend upon Sirvene for the solution to previously "impossible" mechanical sealing and protection problems. Sirvene can also mean success in your search for an unknown pliable part.

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THE *SCIENTIFIC* COMPOUNDED ELASTOMER

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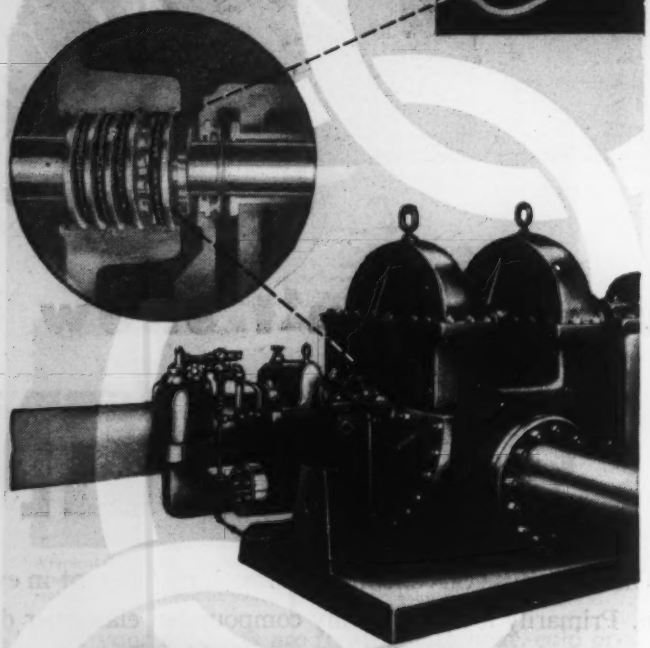
SOLUTION: Morganite Carbon Seals — self-lubricating qualities resist temperature extremes . . . nullify the factor of inaccessibility...are immune to corrosion...prevent wear.



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The successful application of self-lubricating seals in high pressure lines is another example of the basic advantage of Morganite Dry Lubrication — an inherent lubrication that equals the life of the seal without renewal. Full retention of steam, from cold start to full-load high temperatures, is assured. Surface scoring, which opens the way for rapid surface erosion by live steam, is eliminated.

See our CATALOG in SWEET'S FILE — PRODUCT DESIGNERS

For detailed information consult the Morganite Catalog in Sweets File for Product Designers; for engineering counsel, call Morganite

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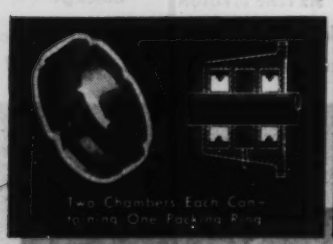
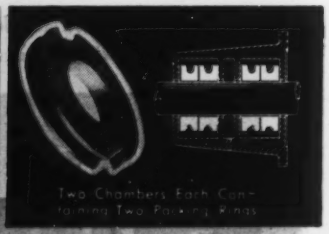
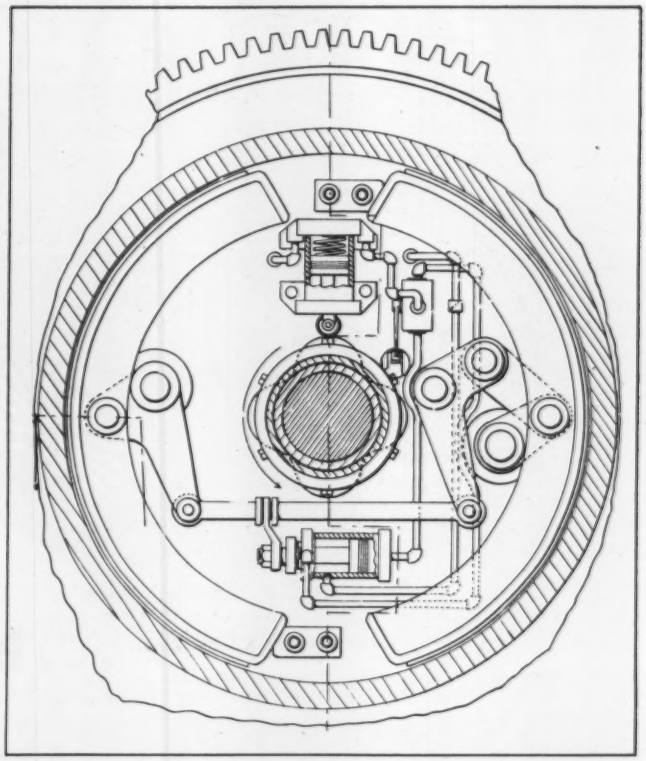


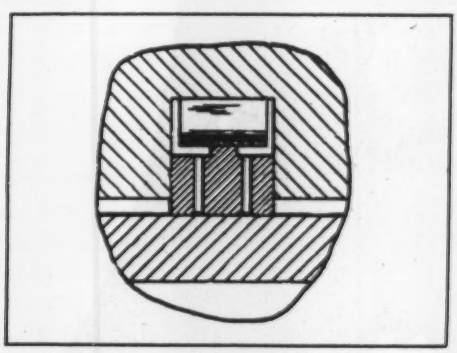


Manufacturers of Morganite Carbon Brushes for all motor and generator applications, and Morganite Carbon Piles.

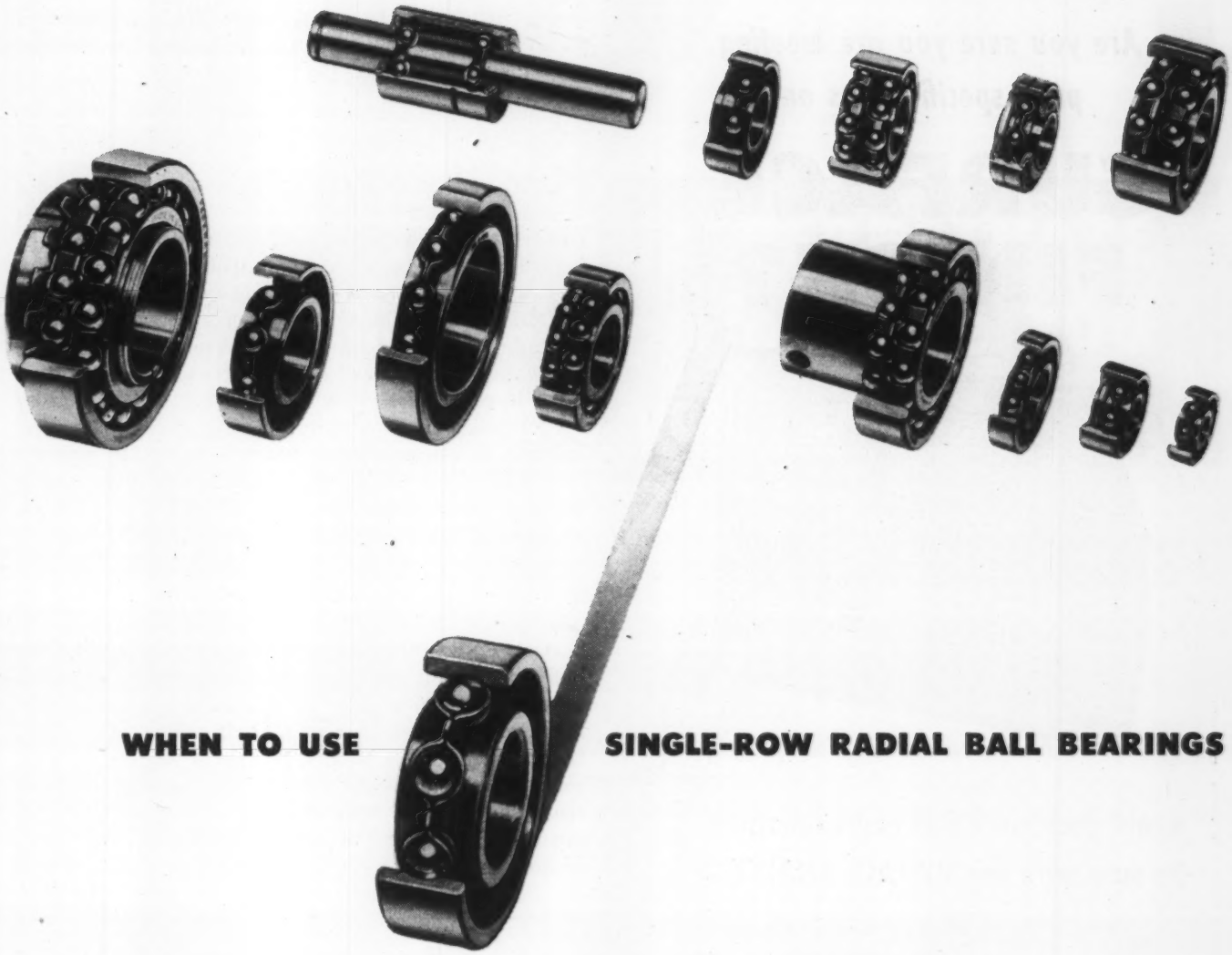


pumping action ceasing when the drum has been brought up to shaft speed. Permitting control of the clutch from a remote point without the use of objectionable ducts or conduits, the unit is well suited to hoist operation or other similar applications.

EFFECTIVE SEALING of shafts subjected to severe vibration, wide temperature changes and high rotational speeds, often impractical with leather or synthetic seals, is accomplished with an all-metal, piston ring type seal covered in patent 2,449,375. The piston ring seal has two rows of staggered slots around its circumference and is compressed slightly along its longitudinal axis to insert it in a groove in the carrier which is threaded onto the rotating shaft. The outer periphery of the seal ring is held snugly



against a sleeve in the journal or housing by an expander spring under the ring. The ring does not rotate with the shaft, sealing engagement existing between the radial walls of the groove in the carrier and the end faces of the seal ring. Pressure applied to the seal tends to urge the ring into firmer sealing



WHEN TO USE SINGLE-ROW RADIAL BALL BEARINGS

Combined thrust and radial loads in any proportion or direction call for deep, continuous races and the largest ball consistent with uniformly heavy ring sections...the kind of precision bearing construction Federal Single-Row Radial Ball Bearings give you.

In Federals, maximum unit pressure per ball is not appreciably increased by the addition of thrust loads up to 50% of the rated radial load. Thrust load is distributed over all the balls in the bearing, while radial load is carried by less than half the balls. For pure thrust the rating is 100% of the radial rating.

Federal Single-Row Radial Ball Bearings are made in light, medium and heavy series, in inch and metric sizes, to cover a wide range of applications. Our Catalog "K" describes these and one of the most complete lines of ball bearings...in every type and size...shielded and sealed...for every anti-friction need. (A few of the many types are illustrated above.) It also includes ball bearing selection charts to help you compute bearing loads, determine load ratings for all bearings at all speeds, and select the type and size bearing best suited to your application. Write for it today.

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Canadian Representatives:
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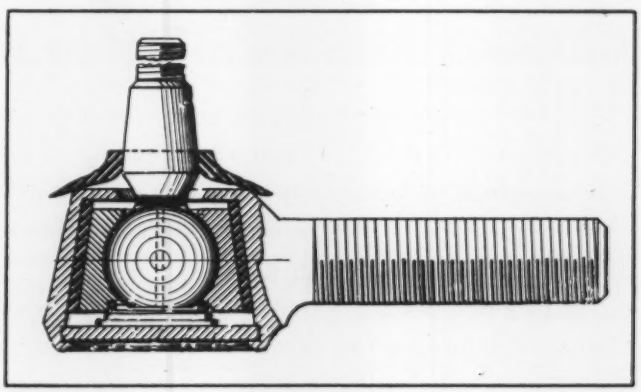
engagement with the low-pressure side of the groove. F. G. Ferguson has assigned the patent to the Simplex Piston Ring Mfg. Co.

REDUCED BLOW-BY and better oil control are obtained with a taper-face piston ring that maintains compression pressure as well as provides a high unit-loaded scraping edge for oil control. The ring is covered in patent 2,459,395 and asigned to McQuay-Norris Mfg. Co. by Dallas M. Smith. The usual disadvantage of tapered-face rings, twisting of the ring in its groove because of unsymmetrical cross-sectional area, is overcome. This ring is machined to a cross section such that when compressed to cylinder size, internal stresses tend to twist it so as to prevent jamming. This twist also forces the sealing edge of the ring into firmer engagement with the cylinder wall and thereby increases the sealing efficiency.

COMPENSATING AUTOMATICALLY for wear, the ball and socket universal joint assembly covered in patent 2,451,060 consists of a tapered socket containing two semicircular conical ball seats surrounding the ball end of a stud. A rubber sleeve between socket and ball seats protect the bearing surfaces from shock loads, wear on the bearing surfaces being taken up by a coil spring urging the ball seats toward the smaller end of the tapered socket, which



lessens the clearance between the ball and its seat. When used as the tie rod joints in automotive applications, the shank of the ball stud and the socket stem are threaded for attachment to the steering assembly. James H. Booth has assigned the patent to Thompson Products Inc.

CONTROLLED LOCKING in selected positions is accomplished with a novel design of garter spring detent for sliding shafts covered in patent 2,451,730. Assigned to the Studebaker Corp. by Harry R. Greenlee, the detent overcomes the shortcomings of conventional ball type detents which are subject to considerable wear and normally cannot be locked. The

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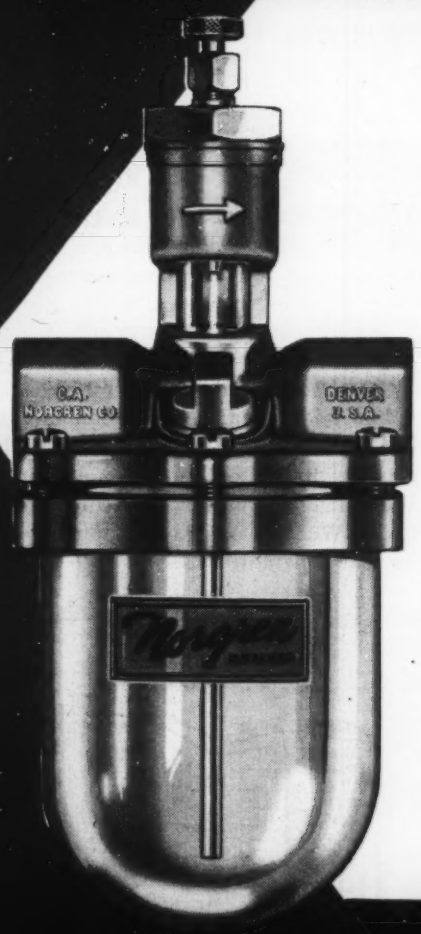

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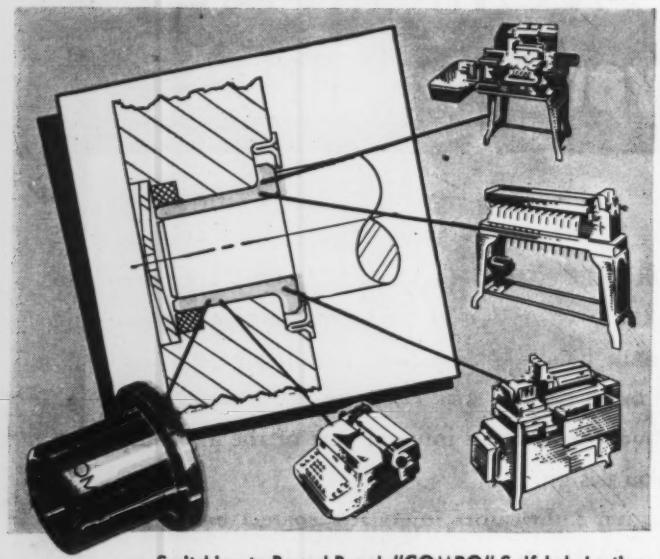
*Names on request



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To the manufacturers:

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- *No periodic lubrication, maintenance costs cut, and continuous, quiet, trouble-free operation.*

"COMPO" Porous Bronze Bearings are made from pure metal powders, die-formed to shape, alloyed at high temperatures, finished to exact dimensions, and vacuum-impregnated with lubricant. Self-lubricating qualities make them ideal for use in inaccessible spots. The lubricant is sealed in, free from dirt, and an even lubricating film is always present.

Thousands of "COMPO" Bearing sizes can be made from existing dies; hundreds of sizes in stock for prompt shipment. Use coupon below, to get our free Stock List or arrange a conference with one of our engineers. *We've saved time and costs for others; we can do the same for you.*

Many other types of "COMPO" Bearings and "COMPO" structural parts have been designed into business machines, appliances and other types of equipment at equal savings and with equal performance benefits.

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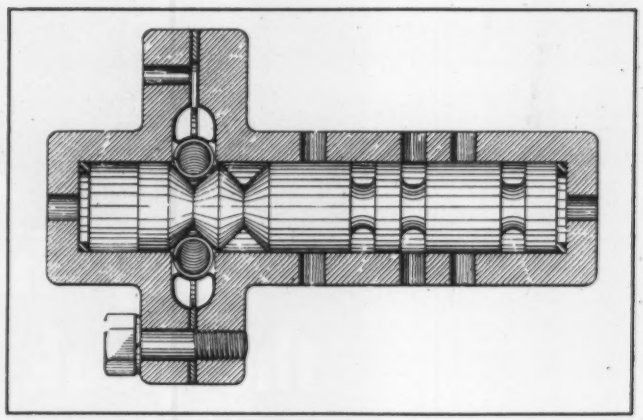
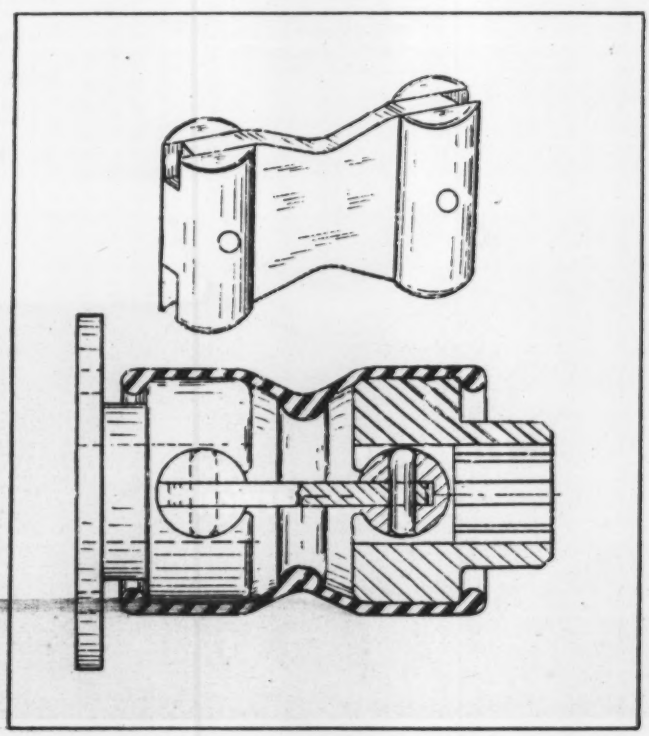
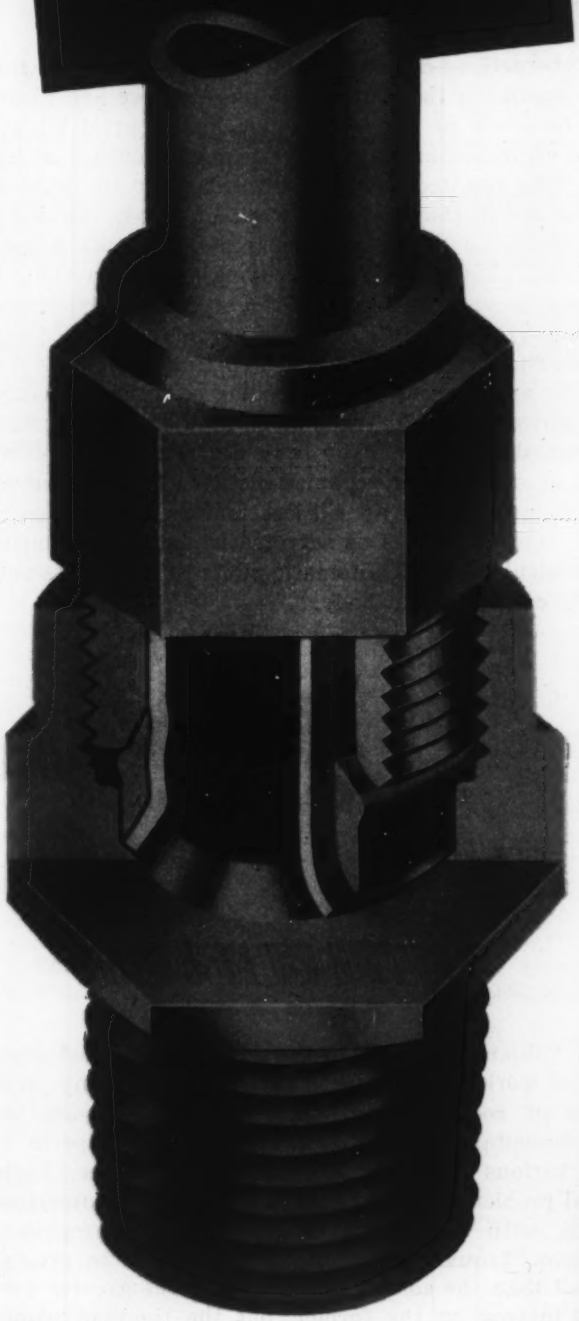


garter spring detent, either round or shaped to fit the detent groove, is surrounded by an annular rubber gland capable of being pressurized hydraulically. Automatic shifting of a detent rod as well as positive locking in position can thus be had by proper control of the pressurizing of the gland chamber actuating the spring detent.

DOUBLE UNIVERSAL OPERATION is accomplished with a simplified joint design which utilizes a flat driving element rocking in cylindrical end pivots. Arranged to be quickly replaceable, the various parts of the unit are held in operating relationship only by means of the heavy rubber dust boot. By rolling back the rubber boot, the drive assembly consisting of drive plate and cylindrical bearing blocks can be easily removed for cleaning, lubricating or replacement. Drive may be by flange or spine connections and the double universal action is obtained in a minimum of length. E. W. Weaver has assigned the patent, No. 2,451,791 to the Towmotor Corp.



Here's a tube fitting you can't shake off— Save time, labor, and material with



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It's a two-piece fitting that makes a perfect flared seal practically by itself . . . is so tight that the tube will burst (but not at the joint) before the fitting leaks . . . and takes repeated disassembly and reassembly in its stride.

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Because of UNIFLARE's unique design, you can use standard wall tubing rather than the much heavier tubing often required to provide the extra strength.

UNIFLARE is available in a complete range of sizes from ⅛ in. through 1 in. and in all the standard shapes. Fully tested and approved by the Underwriters' Laboratories, Inc.

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If you are concerned with the specification or purchase of fittings for gas, oil, air, water or hydraulic lines, take advantage of this opportunity to see for yourself how Scovill's UNIFLARE Fitting can save you time and money. Write on company letterhead for a working sample of Scovill's UNIFLARE Fitting. Address Screw Machine Products Division, 50 Mill Street, SCOVILL MANUFACTURING COMPANY, Waterbury 91, Conn.

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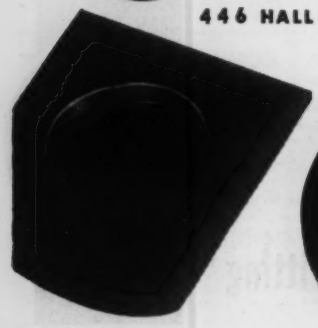

Assets to a Bookcase

Cybernetics

By Norbert Wiener, professor of mathematics, Massachusetts Institute of Technology; published by John Wiley & Sons Inc., New York; 194 *pages,* 6 *by* 9½ *inches, clothbound; available through* MACHINE DESIGN, $3.00 *postpaid.*

Cybernetics—derived from the Greek word for steersman—is the name Professor Wiener has given to the study of the type of machine control known as a servomechanism. Wartime investigations along this line resulted in the realization that the human brain and nervous system work on much the same principles as servomechanisms and computing machines. This book is an analysis of human control functions and the mechanico-electrical systems designed to replace them. It is the outgrowth of extensive theoretical study and experimentation by the author and a group of outstanding scientists—including physiologists, psychologists, mathematicians, and electrical engineers. The book describes the application of statistical mechanics methods to communications engineering, its subject matter ranging from such control devices as servomechanisms, mathematical calculators and automatic pilots to the nerves and brain of the human body.

□ □ □

Rocket Propulsion Elements

By George P. Sutton, supervisor of propulsion development, North American Aviation Inc., Los Angeles; Published by John Wiley & Sons Inc., New York; 294 *pages,* 5⅝ *by* 8⅝ *inches, clothbound; available through* MACHINE DESIGN, $4.50 *postpaid.*

A valuable addition to the somewhat limited number of works dealing specifically with the many problems of rocket propulsion, this book presents the fundamental elements and the practical aspects of the various phases of this new power source. Technical problems and physical mechanisms are described along with the design of the complete propulsion system. Liquid propellants are discussed in greater detail than the solid type because of the greater general interest in the former, but the thermodynamic, thermochemical and ballistic principles presented apply to both types. The last chapter in the book is devoted entirely to the general problems of solid propellant rocket propulsion. Illustrative material includes performance graphs, schematic diagrams and photographs of rockets in addition to frequent tables such as those giving the properties of metals

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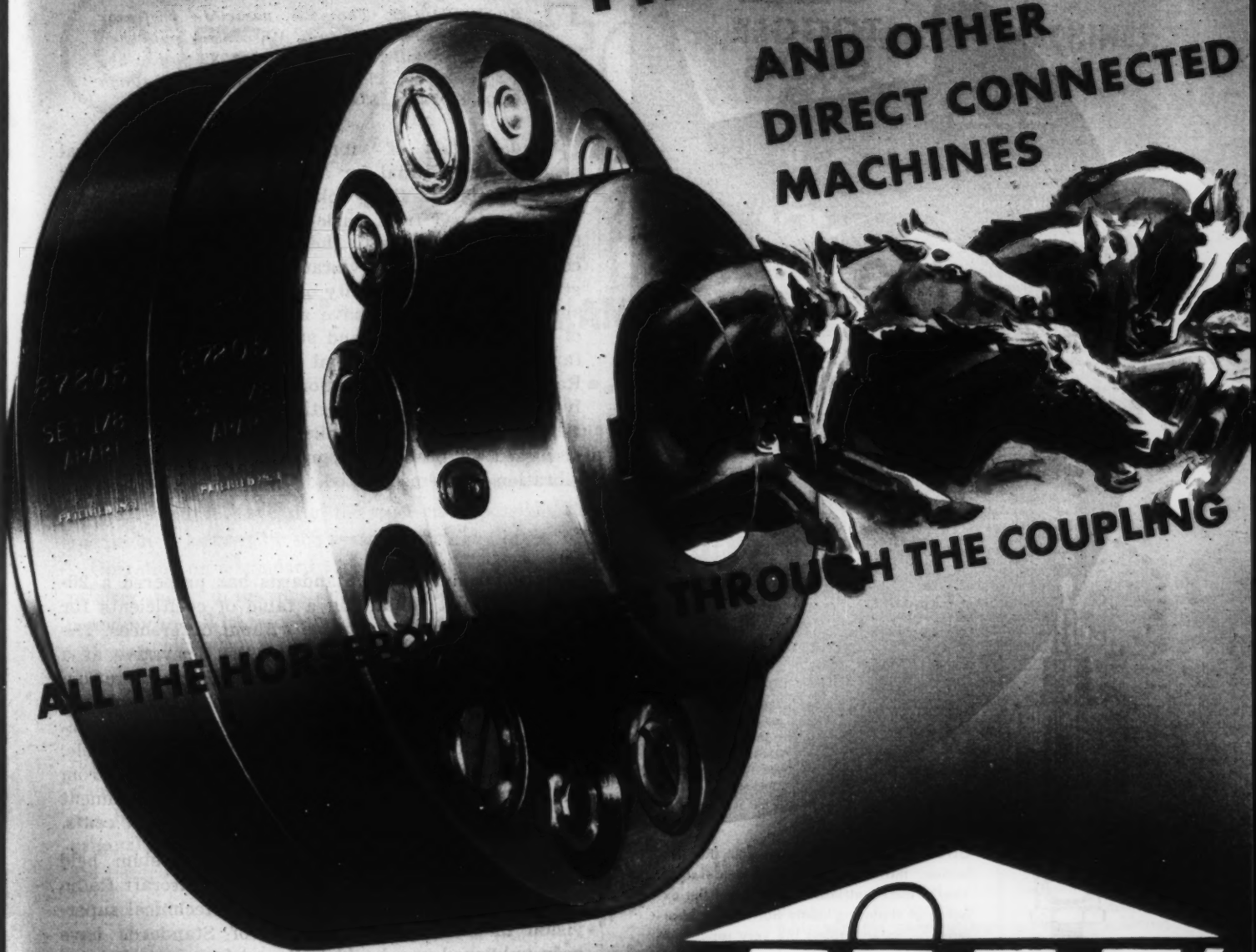

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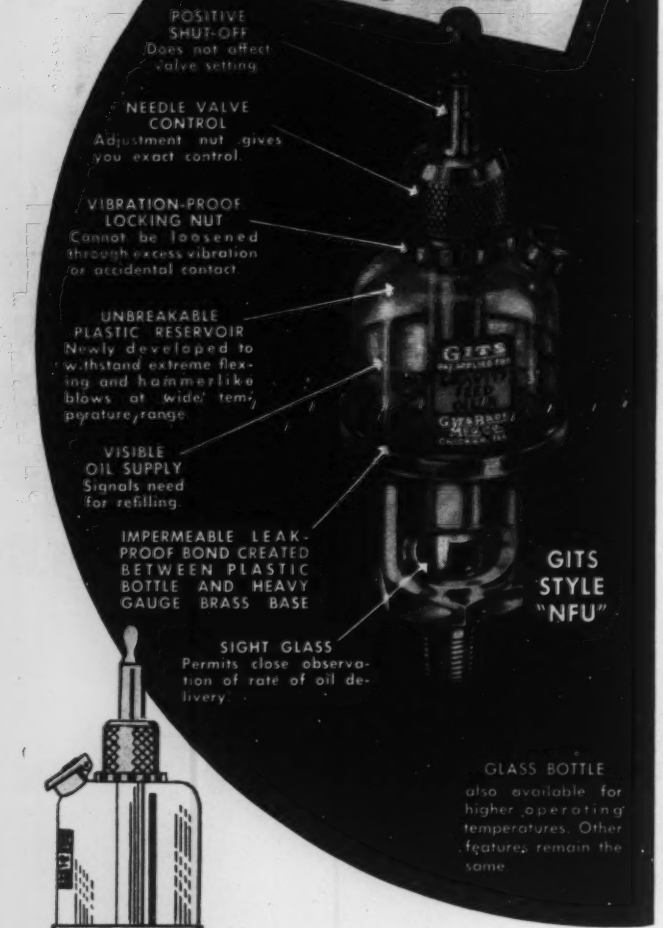

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All the features of the "NFU" PLUS Breather Tube for use where atmospheric conditions within the oiler must be equalized with those in the bearing. Dust-proof. Sight-glass tightly gasketed.

GITS TOGGLE OILERS give you the protection that good equipment deserves. They're excellent insurance against the expense of replacing costly burned-out bearings . . . safeguarding the very reputation that your machines and machine tools have earned through the years. All metal parts except the base are machined from brass bar stock. No question about it, GITS TOGGLE OILERS are your best buy always. Highest quality materials, skilled designs and workmanship see to that!

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at high temperatures. Information on rockets which was restricted from publication until recently because of government regulation is also include.

□ □ □

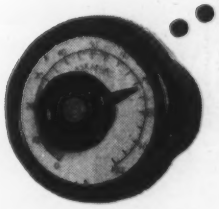
Mechanical Vibrations

By William T. Thomson, associate professor of mechanics, University of Wisconsin; published by Prentice-Hall Inc., New York; 222 pages, 5⅝ by 8⅝ inches, clothbound; available through MACHINE DESIGN, *$5.00 postpaid.*

Fundamentals of vibration theory and general background material for advanced study in the field are presented in this book in which a rational analysis developed from basic fundamentals is emphasized. Following closely the material included in the course in mechanical vibrations offered to graduate students at the University of Wisconsin, the book assumes the reader to have an elementary knowledge of calculus, dynamics and strength of materials. No familiarity with differential equations is presupposed. Rayleigh's method, iteration process, Holzer's analysis, the effective inertia method, Myklestad's tabular method, and Dunkerley's approximation are discussed as practical approaches to the variety of vibration problems treated.

National Bureau of Standards has prepared a 20-page pamphlet containing a table of coefficients for obtaining the first derivative without differences. The table permits the calculation of the derivative at a point within a tabular interval by a single operation. It should be of value in fields of applied mathematics where it is desirable to find the derivative of a function that is tabulated at uniform intervals. The table, Applied Mathematics Series 2, may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 15 cents.

The proceedings of a technical symposium held last year by the Aeronautical Board's Aircraft Radio and Electronics Committee under the technical supervision of the National Bureau of Standards have been published in a booklet, *New Advances in Printed Circuits,* which is now available from the Superintendent of Documents. Topics presented by representatives of industry and government laboratories include the status of printed circuits, conductive silver preparations, printed resistors, trends in military communication, vitreous-enamel dielectric products, printed electronic components on glass, plastics, and other nonconductors, and imprinted circuit inlays. Spraying techniques, mechanization of electrical wiring, die-stamped wiring, and typical commercial applications are also covered. The booklet, NBS Miscellaneous Publication M 192, including 73 pages, 43 illustrations and 6 tables is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. at 40 cents.



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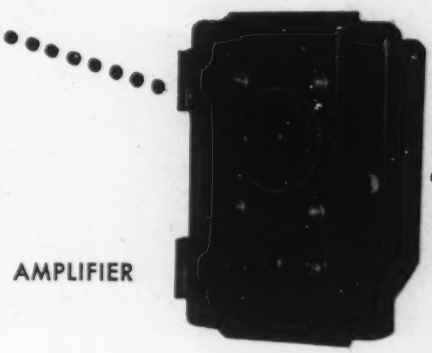
Consider the advantages of operating mechanisms from a remote point up to one thousand feet away — for equipment in a dangerous, inaccessible or inconvenient location. A central control system for several of the receivers is possible. Precise operation is assured by the system's accuracy of ¼ of 1%.

Operating on a standard 115 volt a-c current, the standard receiver shown in the illustration can offer torques up to 220 pound-inches. With the addition of a hydraulic cylinder, torques as high as 7,500 pound-inches can be achieved.

Almost any combination of the three units can be devised to permit multiple networks of transmitters and receivers.

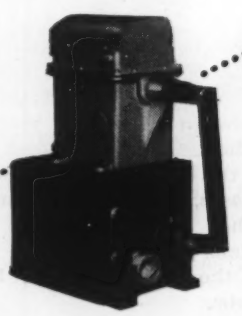
All components of the system are constructed for heavy duty, rugged industrial operation. Dust-proof, cast metal cases withstand shocks, vibration and corrosion. All circuits and tubes can be reached easily without impairing the operation or original installation. Only two electrical supply line connections are needed for the entire system. Write for full information.



AMPLIFIER

Accurate, powerful, simple remote control of dampers, valves, gates, throttles, pumps, machine tools, variable speed settings . . . can be achieved with a combination of the Askania Electronic System components shown in the illustration. A position signal selected at the transmitter or amplifier either manually or by means of cams, gears, or linkages causes the receiver crank arm to change position over a 90 degree arc.

RECEIVER



ASKANIA Controls

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Resistive element embedded in Ward Leonard's exclusive crazeless vitreous enamel, gives these resistors consistent accuracy and stability even under the most prolonged adverse operating conditions.

Write for Resistor Catalog D130. Ward Leonard Electric Co., 58 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD ELECTRIC COMPANY
Result-Engineered Controls
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

Permanent Magnets

(*Continued from Page* 160)

struments is shown in *Fig.* 14. Plugging switches also use this principle to stop reversible electric motors quickly. In this arrangement, the motor's reversing switch is thrown which causes the motor to decelerate rapidly. It is prevented from reversing direction by a device which opens the electric circuit to the motor when the motor speed and, consequently, the eddy-current torque transmission, has become very low.

Slug rejectors for vending machines can be made to sort out nonmagnetic slugs from good coins by causing all coins to roll down an inclined chute and through a magnetic field. Slugs with a higher electrical resistance than normal coins are retarded less by the eddy currents and so land at a greater disance from the end of the chute. Coins with a lower electrical resistance than normal are retarded more and so land a shorter distance from the end of the chute. Good coins land at a point midway between these two and so are the only ones permitted to continue on through the machine.

Eddy-current torque is a consequence of the power expended by the eddy currents and follows the general law: Torque = Power/Angular Velocity, or

$$T = \frac{P}{\omega}$$

$$P(\text{power}) = \int E^2 dC$$

where:

E = the voltage developed
$\mathcal{C}$ = the conductance (reciprocal of resistance)

and the integral of E^2dC is the sum of the power expended around all possible circuits in the conducting disk. Voltage developed is equal to –

$$10^{-8} d\phi/dt$$

where $d\phi/dt$ = the rate of change of flux.

Taking into account all of these factors, the torque is found to be proportional to

$$\frac{B^2R^2At\omega}{r}$$

where:

B = flux density of the magnetic field passing through the disk in gauss
R = mean distance from the center of the rotating disk to the portion through which the magnetic field passes, in inches
A = area of that portion of the disk through which the magnetic field passes, in square inches
t = thickness of disk, in inches
ω = angular velocity, in radians per second
r = specific resistivity of the disk material, in ohms per centimeter cube.

The proportionality constant depends to a large ex-

tent upon the number and arrangement of the magnets and the size of the conducting disk. For an arrangement wherein the area covered by the magnetic field is small in proportion to the whole disk, the value of the torque exerted against the rotation of the disk, in in.-lb, may be approximated by the equation:

$$\text{Torque} = \frac{9.35 \times 10^{-14} B^2 R^2 A t \omega}{r}$$

where the symbols have the same meaning as given previously.

For arrangements where the portion through which the field passes is large in proportion to the whole disk, an estimate must be made of the probable current paths, and the torque computed by proper integration of $E^2 dC$.

The last general classification of magnet functions to be discussed is that of voltage generation. This will not include the large field of ordinary generators as they are not properly a subject for this paper. Magnetic circuits can be arranged to give signal voltages which will indicate speed, differences in speed, or relative angular displacement when measured by electronic devices. In this manner, slippage, angle of twist, and a variety of other quantities can be indicated.

The essentials of such a device are shown in *Fig.* 15. As the toothed wheel rotates, the air gap across which the magnetic flux must travel varies considerably. This gives rise to voltage pulses in the coils in accordance with the well known relation: $E = (10^{-8} N)(d\phi/dt)$.

"I DONT SEE HOW MR. GARTOW EVER GETS ANYTHING DONE . . . HE SPENDS ALL HIS TIME LOOKING AT BLUEPRINTS AND FIGURES!"

because contactor parts are ACCESSIBLE

Removing a single key permits the entire moving contact assembly to be withdrawn for inspection of all main silver contacts, both moving and stationary.

And it's easier to replace main stationary contacts, too, due to the use of individual spring retaining clips.

Write for Bulletin 4110. It fully describes Ward Leonard's new Size 1, 2 and 3 across-the-line, non-reversing AC magnetic starters. Ward Leonard Electric Co., 58 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

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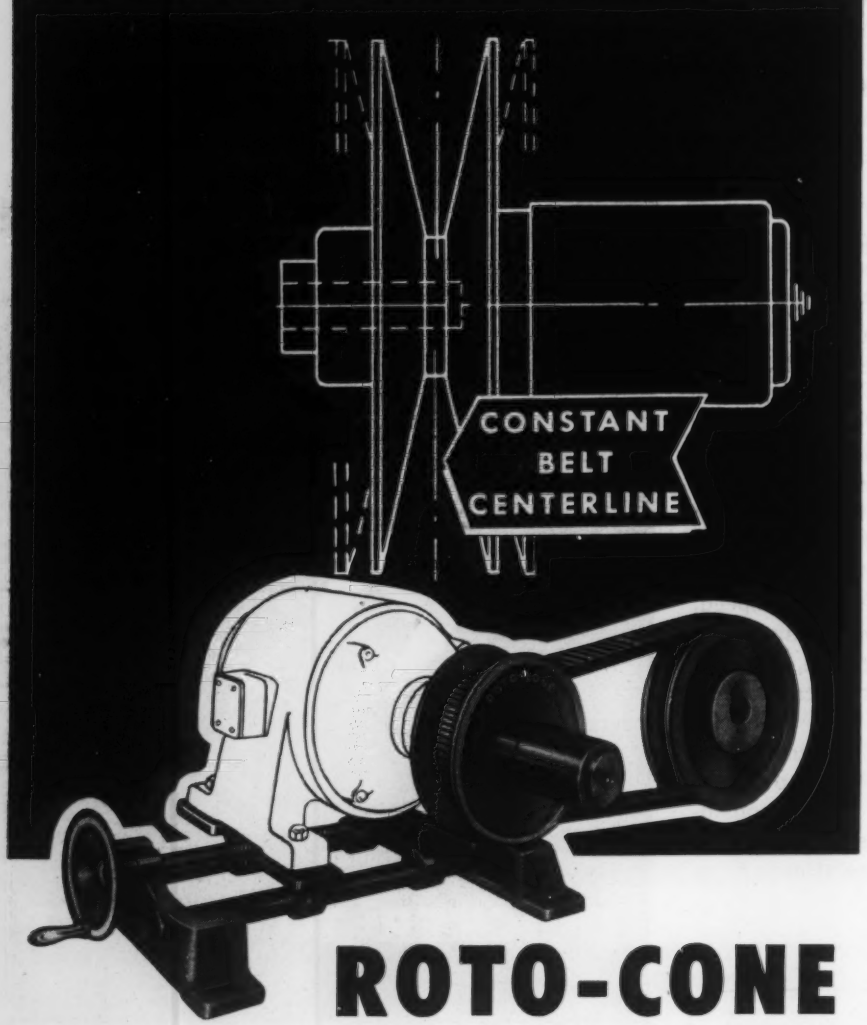
Result-Engineered Controls
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

NEW DESIGN VARIABLE SPEED SHEAVE



ROTO-CONE

V to V drive, longer belt life

Here's infinite speed control with a true V to V drive. Maintaining a constant belt centerline, the ROTO-CONE Variable Speed Pulley permits use of a V-groove driven sheave. Result: Full power and longer belt life wherever speed control is required on *your* equipment.

Wide V belt is used on all sizes . . . meeting all horsepower requirements from 1/8 to 7 1/2. Single spring exerts equal pressure against both sheave faces. Rack and pinion arrangement controls sheave movement.

Sheaves, adjustable motor bases, wide V belts and V-groove driven sheaves are available in all sizes from stock. For details and the assistance of qualified engineers in selecting the ROTO-CONE drive to fit *your* equipment, write or call today!

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complete VARIABLE SPEED DRIVES

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BUSINESS AND SALES BRIEFS

LINK-BELT CO. announces Roy E. Jones has been appointed export manager of the company with headquarters in New York City. He succeeds Carl A. Woerway who is retiring from active service. Mr. Jones began his Link-Belt career at the Philadelphia plant in 1927 and has worked on export sales since 1941.

♦

Announcement has been made of the appointment of Tools Inc. as Philadelphia representative for Illinois Tool Works, Chicago. Tools Inc. specializes in high speed steel and carbide production tools and methods. Officers of the company are D. J. Heckinger and Edmund Hollingsworth.

♦

Change in name has been announced by the Acro Electric Co., Cleveland, to The Acro Switch Co. New directors of the corporation are W. F. Rockwell, W. F. Rockwell, Jr., F. P. Maxwell, Arthur Kroeger and F. G. McCloskey.

♦

Recent election of Victor G. Vaughan as executive vice president of the Spencer Thermostat Div., Metals & Controls Corp., Attleboro, Mass., has been announced. In addition to his Spencer Thermostat activities, Mr. Vaughn will take a more active part in the affairs of the General Plate Div. In the past he has been a vice president of the corporation and general manager of Spencer Thermostat.

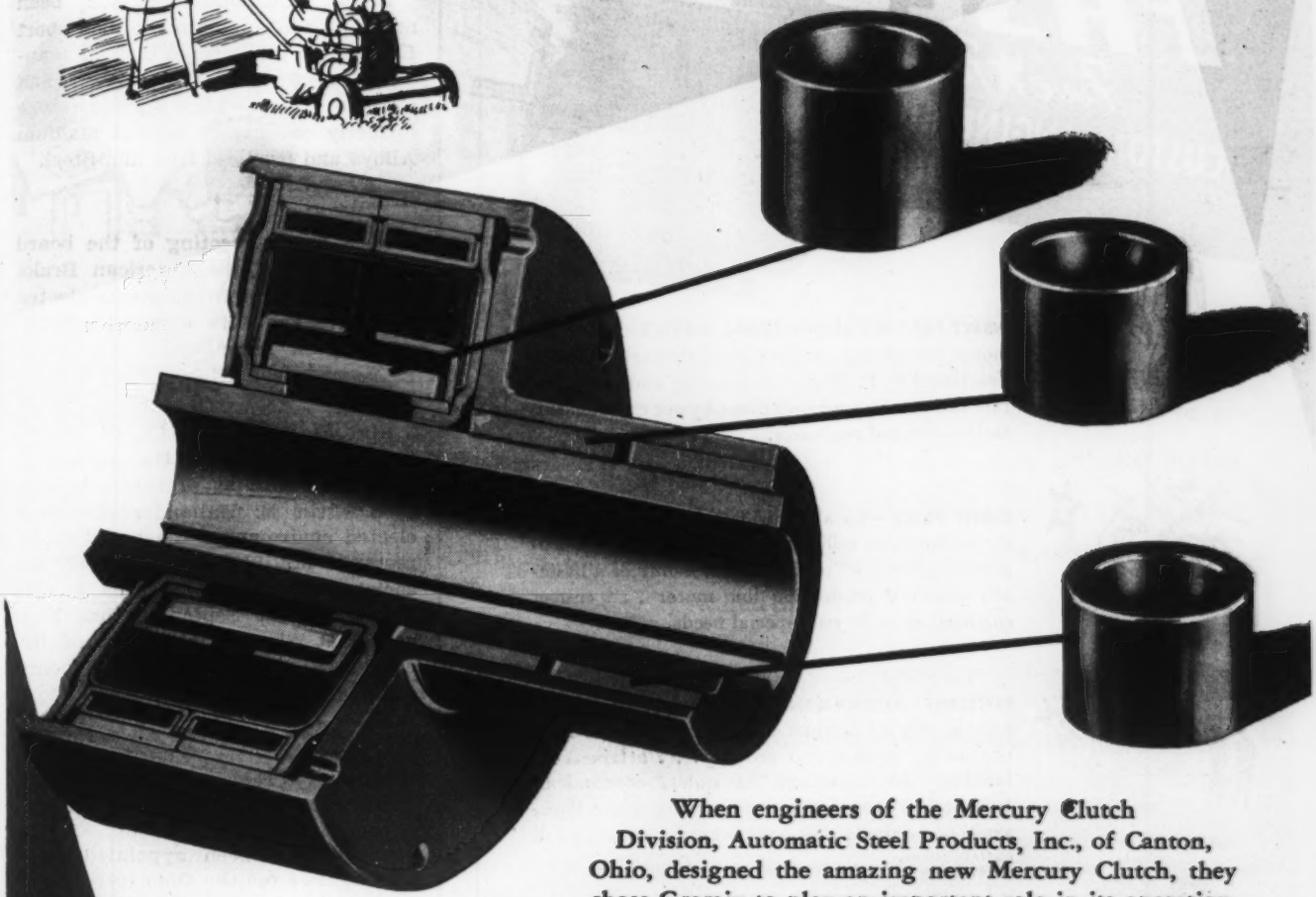
♦

New headquarters for home office and complete manufacturing facilities for J. K. Smit & Sons Inc. is now located in Murray Hill, N. J. A sales office will still be maintained at the present New York location.

♦

Kennametal Inc., Latrobe, Pa. has moved its New York office to 11 West 42nd St. L. D. Morton is acting manager of this office and is assisted by Gerald O. Bogner, John A. Storrs and J. G. Brady. Several new appointments have also been made by the company. C. Russell Miller has been made service engineer working out of

GRAMIX helps Mercury Clutch eliminate power transmission problems



When engineers of the Mercury Clutch Division, Automatic Steel Products, Inc., of Canton, Ohio, designed the amazing new Mercury Clutch, they chose Gramix to play an important role in its operation. The Mercury Clutch automatically controls the application of torque to a load, reducing starting-power demand and protecting the power plant from dangerous overload. In the Type "C" Mercury Clutch shown, two bronze Gramix bushings and an iron Gramix breather ring contribute to the efficiency of the unit. Scores of industries have improved mechanical efficiency and saved money by switching to Gramix bearings, bushings, seals, gears and other parts. Gramix parts can be made to close tolerance dimensions, eliminating the need for further costly machining. Gramix is porous and during manufacture is impregnated with lubrication that normally lasts the life to the part or machine for which it is designed. Our engineers will be glad to study your prints and make recommendations.

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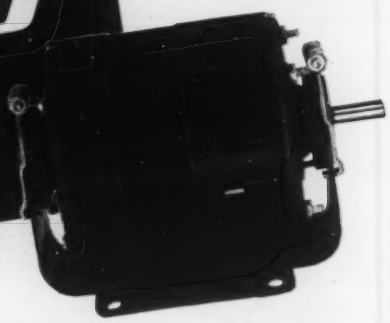
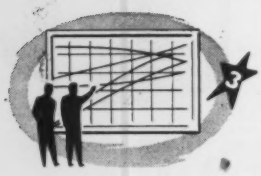
Shaded Pole
1/500 to 1/8 H. P.



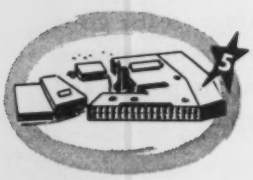
***DIRECT* FACTORY ENGINEERING SERVICE**—Extensive motor technology, accumulated through years of Fractional H. P. Motor engineering and manufacture brought to your own plant by our experienced, factory-trained engineers.

RIGHT PRICE—To allow widest margin in pricing for competitive selling . . . FASCO "Custom Engineering Service" utilizes the economy of a basically *standard* production line motor . . . *custom engineers* it to fit *your* special needs.



EFFICIENT PERFORMANCE—So important to the success of *your* product . . . proved by FASCO'S continuing success and growth . . . attained by building the maximum in quiet, economical, trouble-free operation into motors for many thousands of products that have served users with full satisfaction.

FASCO QUALITY—Adds an extra measure of value to your product. Every step in the manufacture of FASCO Motors . . . from raw stock to final test . . . is under rigid uniform control of the most precise instruments and methods.

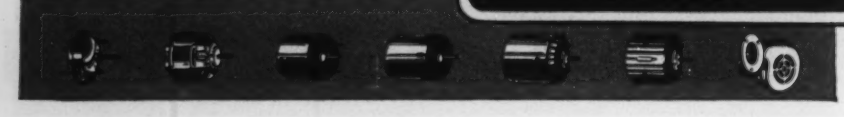


DEPENDABLE MANUFACTURER—Not a giant plant, nor a small one. But a medium-size (250,000 sq. ft.—1,000 employees) well-established reputable manufacturer you can depend on for *delivery* as well as for quality of product.

WRITE on your company letterhead for complete information on FASCO "Custom Engineering Service," and catalog.

***FASCO* INDUSTRIES, INC.**
Formerly F. A. Smith Manufacturing Co., Inc.
ROCHESTER 2, N. Y.

FASCO
FRACTIONAL H.P. SHADED POLE 1/500 to 1/8 H.P.
MOTORS
and
BLOWERS



the Cincinnati office, 2162 Gilbert Ave., Henry B. Worthington will be located at 1537 Main Street, Springfield, Mass., as sales engineer, and Thomas J. Kniff, Jr., has been appointed application engineer with offices at 3701 North Broad St., Philadelphia.

♦

Recent announcement has been made of the appointment of Robert L. Springer as Chicago district manager for Firth Sterling Steel and Carbide Corp. Mr. Springer was formerly associated with Vanadium Alloys and Rustless Iron and Steel.

♦

At a recent meeting of the board of directors of the American Brake Shoe Co. Kempton Dunn was elected vice president and Cyrus E. Brush was chosen secretary.

♦

Star Electric Motor Co. of Bloomfield, N. J. announces the election of Harrie T. Shea as president to succeed Elvin E. Hallander who was elected chairman of the board of directors. Mr. Shea was formerly associated with Bear, Stearns & Co., and since last September has been active at Star as chairman of the executive committee of the board of directors.

♦

Formerly sales manager of the bearing division of Jack & Heintz Precision Industries, Inc., J. L. Feuchter has been appointed service engineer for the Ohio territory of the Federal Bearings Co., Inc., Poughkeepsie, N. Y., making his headquarters at 402 Swetland Bldg., Cleveland.

♦

Appointment of Richard E. Hitchcock as field engineer and sales representative for the New York area of Hannifin Corp. has been announced. Mr. Hitchcock will have his office at 201 Abbott Rd., Fairlawn, N. J.

♦

Formerly sales manager of the Charles Fischer Spring Co., Howard L. Franks has been appointed director of sales of Merrill Brothers, manufacturers of drop forgings.

♦

At the annual meeting of the Aluminum Association, R. S. Reynolds Jr. was elected president for the ensuing year. Mr. Reynolds is an of-

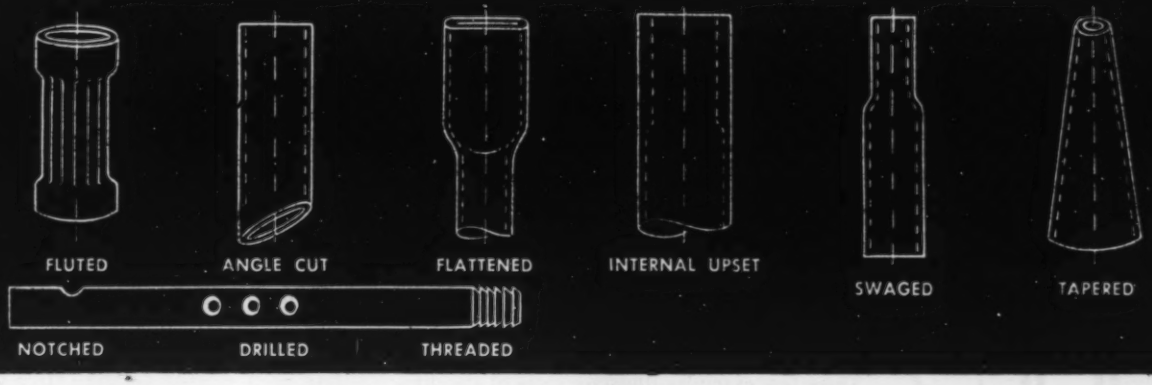
You Draw The Blueprint...

...OSTUCO Does The Work!

The short cut to production savings is as simple as that—you draw up the blueprints and OSTUCO engineers and craftsmen will follow them exactly, producing a finished part or sub-assembly that will simplify your production operations, relieving production bottle-necks, increasing productive output.

OSTUCO's experienced engineers and skilled craftsmen are saving time and money for discerning manufacturers in every field of industry today. Why not check with the nearest Sales Office, to see if your product can be made better, at lower cost, with OSTUCO Tubing, fabricated to meet your most exacting specifications?

Here are a FEW of the things we can do with tubing:



THE OHIO SEAMLESS TUBE COMPANY

Plant and General Offices: **SHELBY 5, OHIO**

Sales Offices: CHICAGO, Civic Opera Bldg., 20 North Wacker Dr. CLEVELAND, 1328 Citizens Bldg. • DAYTON, 1517 E. Third Street DETROIT, 2857 E. Grand Blvd. • HOUSTON, 927 A M&M Bldg. LOS ANGELES, Suite 300-170 So. Beverly Drive, Beverly Hills • MOLINE, 617 15th St. • NEW YORK, 70 East 45th St. • PHILADELPHIA, 1413 Packard Bldg., 15th & Chestnut • ST. LOUIS, 1230 North Main St. • SEATTLE, 3205 Smith Tower • SYRACUSE, 501 Roberts Ave. CANADIAN REPRESENTATIVE: Railway & Power Corp., Ltd., NEW GLASGOW, MONTREAL, NORANDA, NORTH BAY, TORONTO, HAMILTON, WINDSOR, WINNIPEG, EDMONTON, VANCOUVER

AMPCO Metal can really take it!

Exceptional strength... high fatigue limits... wear resistance and resistance to impact

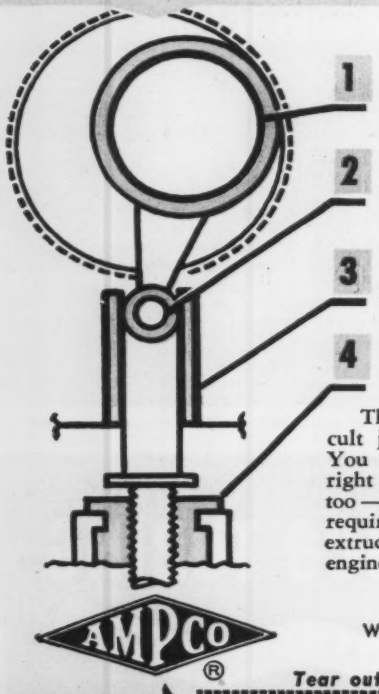
—just the material for your tough jobs!

Possibly you don't make or use heavy presses. But probably you *do* have jobs for Ampco Metal — tough jobs where you need the same superior performance that Ampco Metal gives in these press applications.

*Ampco 24 Extrusion Punch Outlasts the Best Steel 10 to 1

The extrusion punch at the right extrudes a 5/8" hole to 3¼" diameter in a heavy gauge steel water heater head. The best steel punches produced 6600 pieces *maximum.* With the new Ampco Grade 24 punches runs of 65,000 pieces became *average.*

Ampco Bronze in the Press itself!



1 **Bronze eccentric bushings** — Ampco Grade 12 Bushings, centrifugally cast, provide a wear-resistant eccentric bearing lining that gives maximum heavy-duty service.

2 **Bronze wrist-pin bushings** — Ampco Grades 18, 18-23, or 20 centrifugally cast bushings withstand extremely heavy loads without mushrooming. (Ampco field engineers will be glad to recommend proper grade.)

3 **Bronze-lined guides** — Ampco 8 Sheet used as liners (gibs) give maximum life with minimum wear under varying conditions of load, speed, etc.

4 **Bronze liner and locking nut** — Ampcoloy E-123 (centrifugally cast) affords up and down adjustment of shutting height without galling and with minimum wear.

These few examples illustrate some of the difficult jobs which Ampco alloys handle with ease. You can select a grade of Ampco Bronze that is right for your production and maintenance needs too — produced by the method best suited to your requirements: sand or centrifugal castings, sheet, extruded rod, etc. See your nearby Ampco Field engineer for specific recommendations.

AMPCO METAL, INC.
MILWAUKEE 4, WISCONSIN
West of the Rockies it's the Ampco Burbank Plant, Burbank, Calif.

AMPCO®

Tear out this coupon and mail today!

FREE Cost-cutting information on dependable Ampco Bronze Alloys!

AMPCO METAL, INC., Dept. MD-4, Milwaukee 4, Wis.
Send me FREE literature giving complete information regarding Ampco Metal and Ampco Bronze Alloys!

Name..... Position.....
Company.....
Address.....
City..... ( ) State.....

ficer of the Reynolds Metals Co., Richmond, Va. Vice presidents elected at the same time were: E. G. Grundstrom, Advance Aluminum Castings Corp.; M. E. Rosenthal, United Smelting and Aluminum Foundry Inc.; and George N. Wright, the John Harsch Bronze and Foundry Co. A. V. Davis, Aluminum Co. of America, was re-elected chairman of the board and Donald M. White was reappointed secretary and treasurer.

♦

Promotion has recently been announced of James R. Derrick to assistant sales manager of the Pennsylvania Flexible Metallic Tubing Co. Mr. Derrick has been associated with Penflex for a number of years in the sale and application of flexible tubing.

♦

The firm of Carlso'n Inc. has recently been formed to design and manufacture special machinery including resistance welding equipment. Officers of this Warren, Ohio, organization are A. L. Carlson, president, L. R. O'Neill, vice president, and H. A. Stix, secretary and treasurer.

♦

According to a recent announcement, Richard E. Hall has been assigned to the Boston office of the American Phenolic Corp. Mr. Hall will cover the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut. His office will be in the United Building, 43 Leon St., Boston 15.

♦

Succeeding F. W. Mesinger, who has resigned, Ralph O. Wirtemburg has been appointed sales manager of the Norma-Hoffmann Bearings Corp. At the same time, Erwin J. Schmiel has been elected to the office of secretary-treasurer, succeeding E. C. Lennon, who has retired after 35 years service with the corporation.

♦

The R-S Products Corp., Philadelphia manufacturers, have appointed the Trident Engineering Co., San Francisco, as West Coast representatives of their valve division.

♦

An electronics and aircraft equipment division is being formed by the Standard-Thomson Corp., manufacturers of automotive and aviation parts. Located at 930 Ludlow St.,

"Me . . . stock all those endless V-Belt sizes?"

"Not since I use VEELOS"

"I can replace any V-belt in our plant with just these reels of Veelos."

That's a typical Veelos user telling you how Veelos cuts V-belt inventory. If you use O, A, B and C widths, four reels of Veelos give you a choice of more than 316 sizes. Use only A and B? Then two reels are all you need.

Buying matched sets of endless V-belts is costly. Forget it with Veelos. Forget, too, belt deterioration and obsolescence. Veelos on reels saves storage space . . . simplifies stock records.

Veelos is quickly and easily installed. On drives with fixed centers or outboard bearings, Veelos is installed without moving the motor or dismantling the machine. It provides substantial savings in installation and maintenance costs.

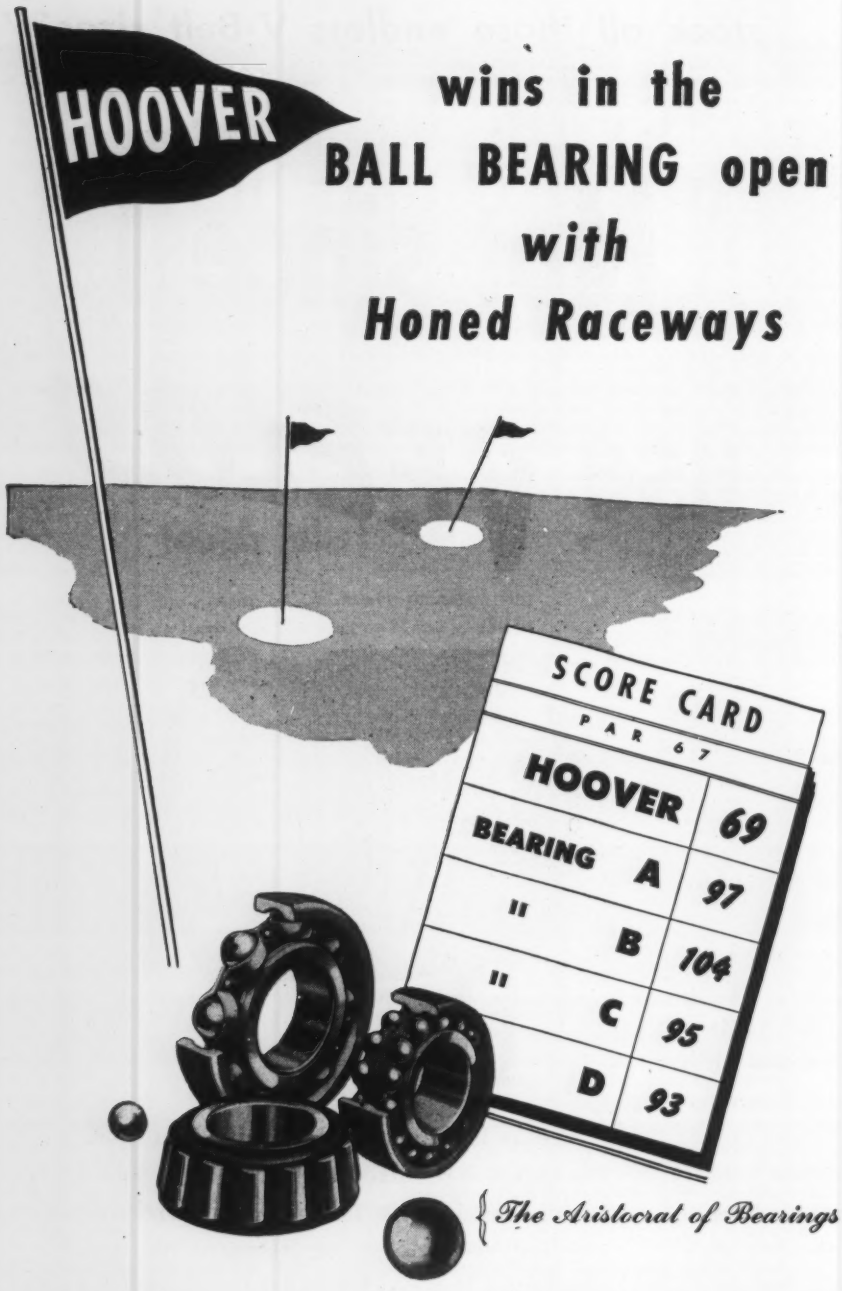
VEELOS
THE LINK
V-BELT

SEND FOR FREE VEELOS CATALOG. It shows how you can benefit from the many important advantages of Veelos. Fully illustrated. Complete engineering data. Write for it.

MANHEIM MANUFACTURING & BELTING COMPANY
MANHEIM, PA.

ADJUSTABLE TO ANY LENGTH • ADAPTABLE TO ANY DRIVE

Made in all standard sizes, fits all standard grooves. Packaged on reels in 100-foot lengths. Sales engineers in principal cities; over 300 distributors throughout the country. Veelos is known as VEELINK outside the United States.



HOOVER wins in the BALL BEARING open with Honed Raceways

The Aristocrat of Bearings

In golf, low score makes the champion. With bearings, low score in quietness is evidence of the championship anti-friction performance. These scores are obtained by measuring, in a scientific radio sound test, Anderons of sound of the ball bearing in operation. Recently Hoover ball bearings were sound tested in competition with four other nationally known makes. Three hundred and fifty ball bearings, of the same sizes and quality, were tested. Hoover Ball Bearings with Honed Raceways scored 24 Anderons lower than the nearest competitor! Would such championship performance, at a reasonable cost, add to the value of your product? A request, on your letterhead, will bring you a copy of the Hoover Engineering Manual.

HOOVER

America's Only Ball Bearing With Honed Raceways

HOOVER BALL AND BEARING CO. ANN ARBOR, MICH.

Dayton, the new division will be under the direction of James P. Malmstrom, formerly associated with Harris-Seybold Co. as a project engineer and production supervisor.

♦

Four-fold plant expansion has been announced by Kenmore Metals Corp., manufacturers of wire. The organization's present facilities in Warren, Pa., will be moved to Jersey City, N. J. where they will occupy the former sight of the American Brake Shoe Foundry, 380 9th St.

♦

Formerly sales promotion manager for industrial products of the B. F. Goodrich Co., Chester F. Conner has been appointed manager of the industrial products sales department of the industrial and general products division.

♦

Elected chairman of the board of the Standard Varnish Works, J. Heath Wood has resigned his posts as president of the Standard Varnish Works of New York and Standard Varnish Works of Illinois. He is succeeded by M. H. Corbin and E. E. Day at the New York and Illinois works, respectively.

♦

Appointment of two district sales managers for the chemical division of the Goodyear Tire & Rubber Co. has recently been made. Donald E. Reese has been named New York manager, and John W. Bear, Philadelphia manager.

♦

Associated with Hydropress Inc. for the last three years as sales engineer, Carl E. Haugh has been appointed district sales manager of its eastern and midwestern divisions.

♦

Albert A. Goodson Jr. has been appointed district sales manager for the Texas territory of the Penn Metal Co. inc. With offices at 3802 Ruth St., Houston, Mr. Goodson succeeds W. N. Spires who died recently.

♦

Pittsburgh district sales manager for Superior Steel Corp. since 1946, Fred L. Fox has been appointed assistant general manager of sales in charge of clad metal sales. Walter G. Blume continues as assistant general manager of sales in charge of stainless steel, and Fred K. Myers

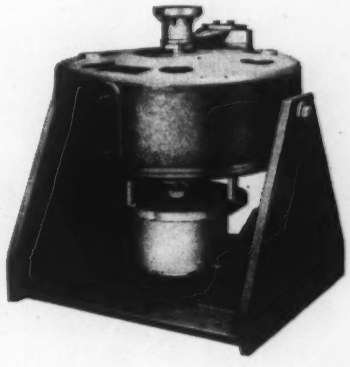
How to deal effectively with VIBRATION:

Locate it- ...with an MB PICKUP

Any trace of vibration comes to light when you attach this sensitive electrical pickup to your product. A rugged, precision-built product, it will withstand rough treatment.

When bolted to equipment under test, this velocity-type pickup faithfully converts vibratory motion to an electrical output. Signal can be visualized with an oscilloscope. Major industries today find it indispensable for accurate analyses. Write for bulletin 124.

Reproduce it- ...with an MB EXCITER



You can't beat this electro-dynamic exciter for shaking "bugs" out of products. With its frequency and force adjustments, you can "scan" a product for vibratory response—or fatigue-test it.

Take one case where a manufacturer of turbines was beset by blade failures. With an MB Exciter, he was able to resonate blades to destruction quickly—while studying their motions with stroboscopic light. In this way, he got to the cause of the trouble *visually!* More data in our bulletin 210B.

Isolate it- ...with ISOMODE* MOUNTS

Because Isomode mounts have equal spring rates in all directions, they're efficient at all angles — and they isolate all modes of motion!

That's why, by adopting Isomode units, one company was able to simplify suspension brackets and save on manufacturing costs in *addition to* improving vibration control! Another has been better able to cushion heavy duty engines—*without* redesigning the mounting system! Ask for bulletin 202 and Design Chart.

**Trade Mark Reg. U.S. Pat. Off.*

You can see why more and more engineers contact MB when they run into trouble with vibration. We'll be happy to cooperate with you on *your* problems. For more information and for bulletins on the above MB products, write to Dept. E 3.

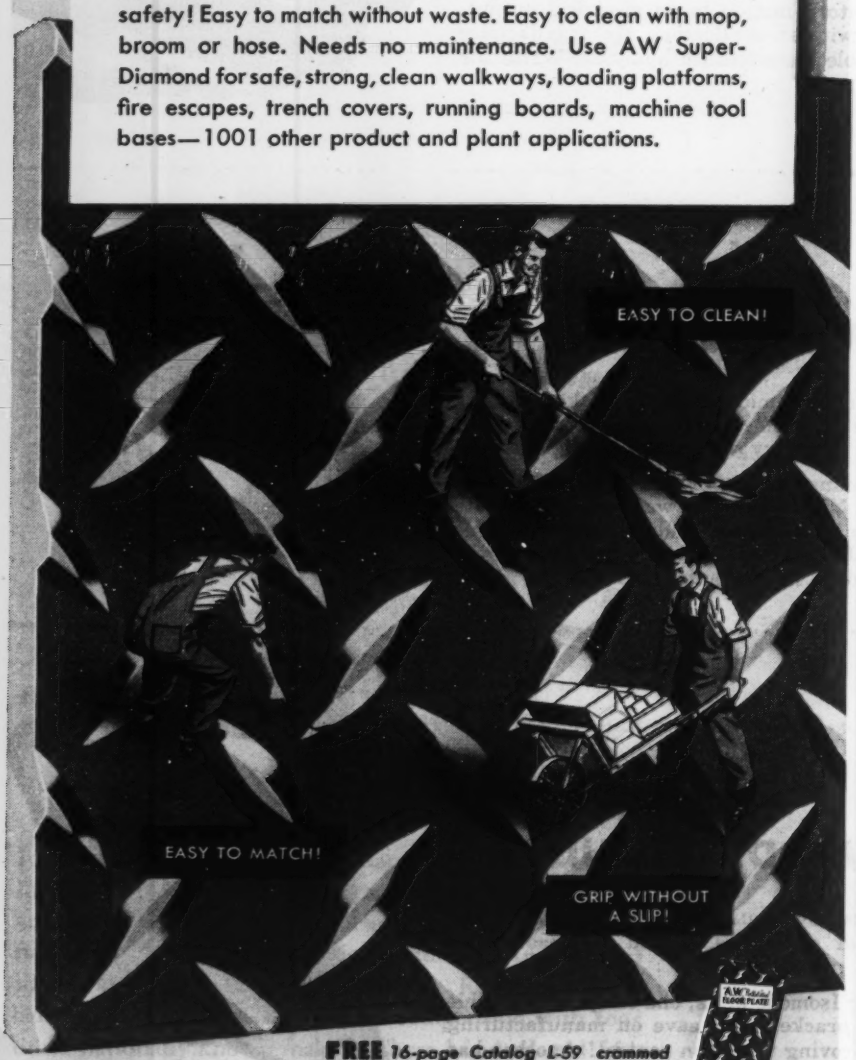
THE MB MANUFACTURING COMPANY, INC.
1060 State Street
New Haven 11, Conn.
VIBRATION ISOLATOR UNITS • VIBRATION TEST EQUIPMENT
VIBRATION DIVISION

No More Slipping Accidents!

AW SUPER-DIAMOND FLOOR PLATE

A Better Footing for Product and Plant

Put this floor plate in your plant—or on your product—and say goodbye to costly slipping accidents. Even when the surface is wet or oily, exclusive engineered design with Super-Diamonds at 45° angles gives grip-without-a-slip safety! Easy to match without waste. Easy to clean with mop, broom or hose. Needs no maintenance. Use AW Super-Diamond for safe, strong, clean walkways, loading platforms, fire escapes, trench covers, running boards, machine tool bases—1001 other product and plant applications.



FREE *16-page Catalog L-59 crammed with valuable information. Write now.*

AW SUPER-DIAMOND
FLOOR PLATES THAT GRIP

A Product of ALAN WOOD STEEL COMPANY
Conshohocken, Pa.

Other Products: Permaclad, Stainless Clad Steel • AW Super Grip, Abrasive Floor Plate • Billets • Plates • Sheets (alloy and special grades)

continues as assistant general manager of sales in charge of carbon, alloy and spring steel.

♦

Election of John C. Wilson as a director and vice president in charge of sales has been announced by the board of directors of the Thompson Grinder Co. Mr. Wilson has, in the past, held the posts of chief engineer and sales manager of the company.

♦

Eastern plant has been established by G. M. Giannini & Co., manufacturers of automatic flight equipment. Located at 697 Morris Turnpike, Springfield, N. J., the plant will be under the direction of Charles H. Colvin, recently elected vice president of the corporation.

♦

Wellington Sears Co., selling agents for the West Point Mfg. Co., have announced the formation of a new department to handle sales of Lantuck, a new type bonded, or nonwoven, fabric.

♦

Formerly associated with the Elliott Co. as executive vice president and as a director, Frank H. Stohr has been named general manager of the Allis-Chalmers Mfg. conmany's Norwood works. He succeeds R. W. Davis, general manager of the plant since 1944.

♦

With offices at 317 S. Detroit Ave., Tulsa, Okla., the Ardun Co. has been appointed a distributor of Tube-Turns welding fittings and flanges.

♦

Among recent sales appointments made by SKF Industries Inc., Stuart H. Smith has been named Cincinnati district manager. Field representatives appointed were: C. N. Benson and D. B. Eden in Boston; A. R. Ehrnschwender in Cincinnati; J. T. Paradise in Atlanta; and G. L. Hansen in Portland, Ore.

♦

With offices in Smith Tower, Seattle 4, W. R. Hendrey Co. is the new Washington and Oregon representative of Marcus Transformer Co.

♦

According to a recent announcement, Robert F. Smith, vice president and sales manager of the Indiana Steel Products Co. since 1947, has

WINTER COLDNESS IS SEALED IN
—with the help of *Spongex* sponge rubber!

Even for small fry the modern refrigerator has varied and wonderful uses. And even in their lives *Spongex* sponge rubber is playing an increasingly important part to make the way pleasanter, smoother, quieter and easier.

Spongex today is used in an almost infinite number of products, ranging from refrigerator door seals to shoe insoles—from all kinds of seals and gaskets, motor suspension pads, seat cushions and backs, to weatherstripping, radio rubber parts and toys.

All the cushioning, sound deadening, sealing and insulating properties of rubber have been multiplied in *Spongex* and precisely engineered to do a specific job. And *Spongex* does a *better* job because it's made by a company that for 25 years has concentrated on making rubber do a better job of cushioning, insulating, sealing.

See the difference, feel the difference, prove the difference such experience makes. Send now for generous samples of *Spongex* to test for resiliency, cell structure, tensile strength and resistance to temperature extremes, moisture, acids, corrosive vapors, abrasion and aging. Write today, naming your product and problem. Sponge Rubber Products Co., 129 Derby Place, Shelton, Conn. Sales offices in principal industrial centers.

Trade Marks Reg. U. S. Pat. Off.

SRP

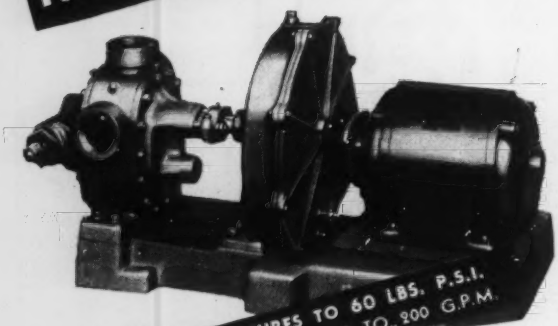
SPONGE RUBBER PRODUCTS CO.

SPONGEX • CELL-TITE • TEXFOAM • TEXLITE • TEXLOCK

Rugged— These ROPERS ...and Dependable!

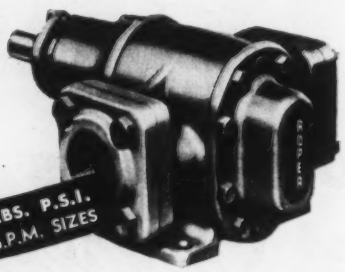
PUMPS ENGINEERED TO FIT YOUR NEEDS

Roper manufactures an extensive line of precision-built pumps to handle a multitude of applications for industries of all types. Illustrated are three examples of pumps in Roper Series 3600, K, and F — each representative of varying pressure and capacity ranges.



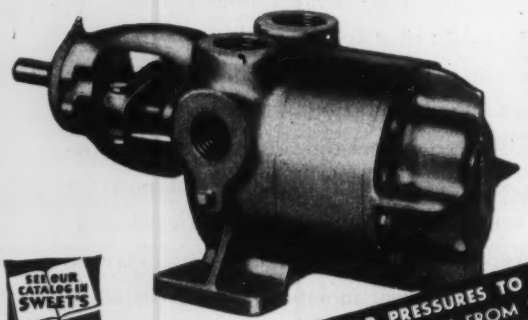
FOR PRESSURES TO 60 LBS. P.S.I.
CAPACITIES FROM 40 TO 200 G.P.M.

FIG. 3600 MARV—A general purpose motor driven unit designed to handle thin or heavy viscous liquids at slow speeds. Has built-in relief valve, oil enclosed gear guard, babbitted bearing support, bed plate and coupling; fitted for standard motor frames. Other models rated also from 40 to 200 g.p.m.



FOR PRESSURES TO 150 LBS. P.S.I.
CAPACITIES IN 30, 40, 50 G.P.M. SIZES

FIG. 1K with Packed Box—Supplied in 30, 40, and 50 g.p.m. sizes with companion flanges. Especially suited for fuel supply or transfer work. New Roper venturi suction and discharge principle minimizes energy loss caused by cavitation, turbulence, or friction. Other models available in ¾ to 50 g.p.m. sizes.



SEE OUR CATALOG IN SWEET'S

FOR PRESSURES TO 300 LBS. P.S.I.
CAPACITIES FROM 1 TO 300 G.P.M.

FIG. 1F—Features four-port design offering eight optional piping arrangements. Hydraulic self-lubricating principle prolongs pump life; can be direct connected or belt driven; ideal for pumping clean liquids of all kinds. Other models — including relief valve models—available in 1 to 300 g.p.m. sizes.

Send for Catalog on Complete Line

Illustrating and describing pumps built to handle pressures up to 1000 lbs. p.s.i., capacities ¾ to 300 g.p.m., at speeds up to 1800 r.p.m.

ROPER *Rotary Pumps*

GEO. D. ROPER CORPORATION, 244 Blackhawk Park Ave., Rockford, Ill.

been elected to the newly created post of vice president and general manager. Succeeding Mr. Smith as vice president and sales manager is Frank A. Hayden, formerly Eastern sales manager for the company.

♦

Formerly located at 1406 S. Grand Ave., Los Angeles, J. C. van Groos, West Coast representative for the Superior Electric Co., has moved into new quarters at 1436 N. Serrano Ave., Hollywood 27, Calif. New location will afford greater facilities and provide warehousing space.

♦

American Weldment Manufacturers Association has recently announced its official insignia. Consisting of the four capital letters AWMA printed in white against a dark background, the insignia will be used in advertising, literature and other printed matter published by the organization and its member companies.

♦

For the past six years manager of the Hydraulic Press Mfg. company's Cleveland and Pittsburgh offices, C. R. Terry has resigned and organized the Terry Machinery Co. for the sale of metalworking machinery. Location of the newly formed company is Hanna Bldg., Cleveland.

♦

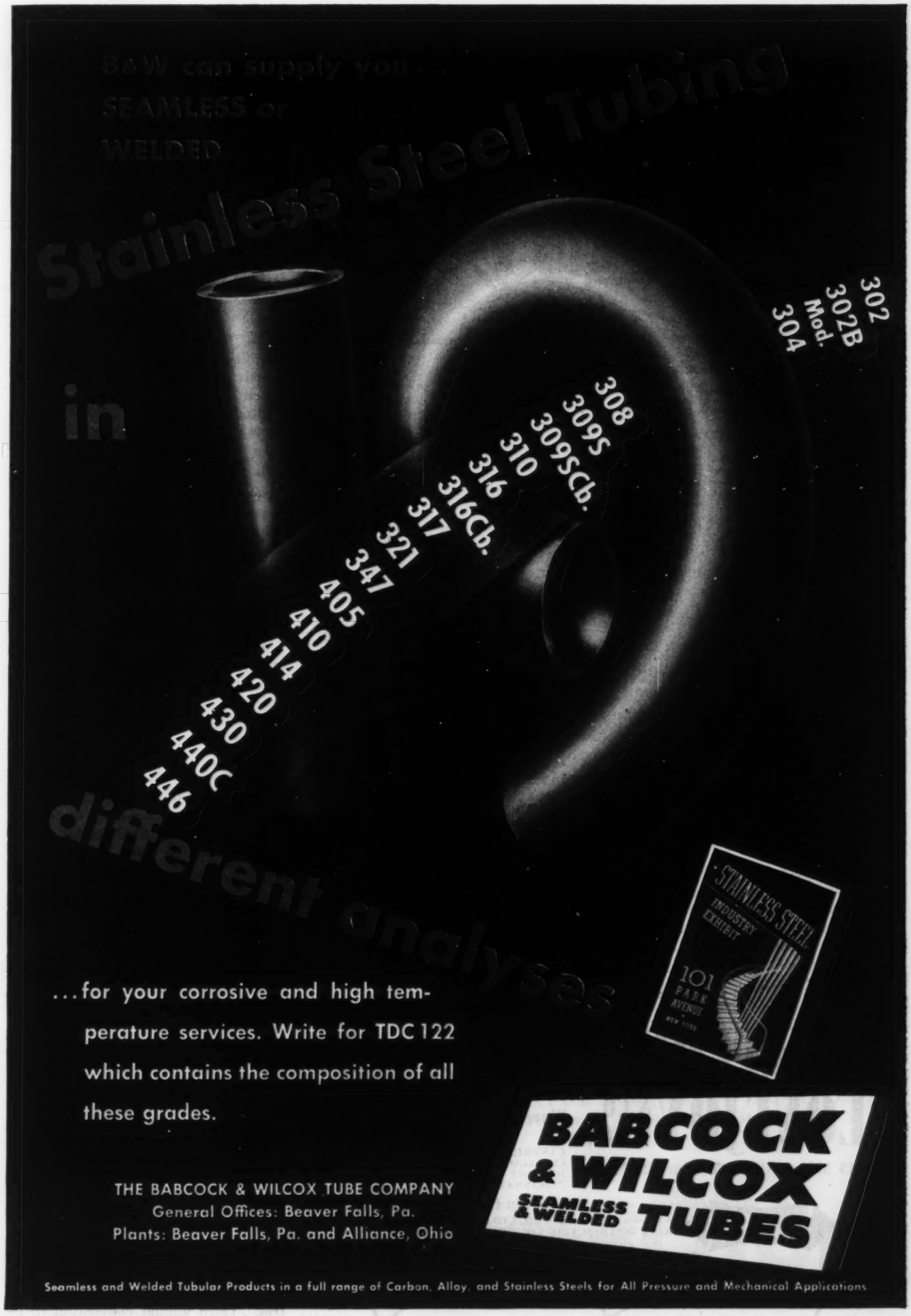
Henry T. Chamberlain has been elected president of Thompson-Bremer & Co. succeeding Arthur H. Thompson who has been elected chairman of the board of directors. At the same time William J. Dunn was elected vice president. Mr. Chamberlain was for many years dean of the school of commerce and business manager of Loyola University and a partner in the public accounting firm of Touche, Niven, Bailey & Smart. Mr. Dunn for the past nine years has been sales manager of the hydraulic division of New York Air Brake Co. in Chicago.

♦

Larger quarters have recently been acquired by Standard Locknut and Lockwasher Inc. The new, larger, facilities are located at 118 West St. Clair St., Indianapolis.

♦

Announcement of the appointment of Wilson W. Wheeler as sales manager of Askania Regulator Co., Chicago, has been made.

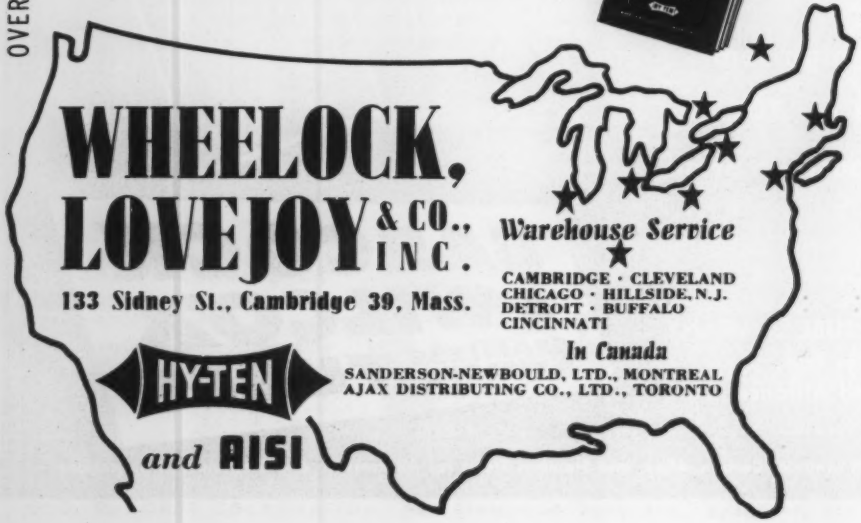

B&W can supply you . . .
SEAMLESS or
WELDED
Stainless Steel Tubing
in
different analyses
302
302B
Mod.
304
308
309S
309SCb.
310
316
316Cb.
317
321
347
405
410
414
420
430
440C
446
STAINLESS STEEL
INDUSTRY EXHIBIT
101 PARK AVENUE
NEW YORK
. . . for your corrosive and high temperature services. Write for TDC 122 which contains the composition of all these grades.
THE BABCOCK & WILCOX TUBE COMPANY
General Offices: Beaver Falls, Pa.
Plants: Beaver Falls, Pa. and Alliance, Ohio
BABCOCK & WILCOX
SEAMLESS & WELDED TUBES
Seamless and Welded Tubular Products in a full range of Carbon, Alloy, and Stainless Steels for All Pressure and Mechanical Applications

OVER ONE HUNDRED YEARS OF CONTINUOUS SERVICE. ROUNDS, SQUARES, FLATS, HEXAGONS, OCTAGONS
BILLETS AND FORGINGS FOR PRODUCTION, TOOL ROOM AND MAINTENANCE REQUIREMENTS.

The selection of alloy steel grades necessarily varies with each manufacturer's needs and opinions. Some prefer HY-TEN alloy steel, while others recommend standard A. I. S. I. steel. However, differences in choice need not mean different sources of supply . . . just contact the Wheelock, Lovejoy warehouse nearest you. There you will find all grades of HY-TEN alloy steel as well as standard A. I. S. I. . . . grades to meet every need and opinion. By dealing with Wheelock, Lovejoy, you have the advantage of prompt delivery from a nearby source, plus courteous help from men who know metallurgy.

WL *steels are metallurgically constant. This guarantees uniformity of chemistry, grain size, hardenability—thus eliminating costly changes in heat treating specifications.*

Write today for your FREE COPY of the Wheelock, Lovejoy Data Book. It contains complete technical information on grades, applications, physical properties, tests, heat treating, etc.



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Meetings and Expositions

Apr. 18-20—

Midwest Power Conference sponsored by the Illinois Institute of Technology to be held at Sherman Hotel, Chicago. Dr. E. R. Whitehead, 3300 South Federal St., Chicago 16, Ill., is conference secretary.

Apr. 19-20—

The Magnesium Association. Annual spring meeting and product exhibit to be held at the Edgewater Beach Hotel, Chicago. T. W. Atkins, 30 Rockefeller Plaza, New York, N. Y., is executive vice president.

Apr. 25-28—

Southern Machinery and Metals Exposition to be held at the Municipal Auditorium, Atlanta. Michael F. Wiedl, 267 E. Paces Ferry Road, N. E., Atlanta 5, Ga., is managing director.

Apr. 25-29—

American Society of Mechanical Engineers. Oil and gas power division conference to be held at Hotel Sherman, Chicago. C. E. Davies, 29 West 39th St., New York 17, N. Y., is secretary.

May 2-4—

Amercian Society of Mechanical Engineers. Spring meeting to be held at Hotel Mohican, New London, Conn. C. E. Davies, 29 West 39th St., New York 17, N. Y., is secretary.

May 2-5—

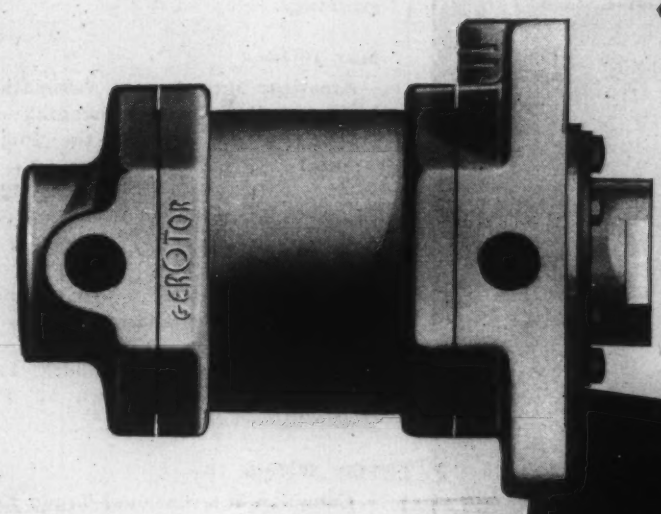
American Foundrymen's Society. 1949 Foundry Congress to be held in St. Louis. Additional information may be obtained from headquarters of the society at 222 W. Adams St., Chicago 6, Ill. William W. Maloney is secretary.

May 2-13—

British Industrial Fair to be held at Earl's Court and Olympia, London; and at Castle Bromwich, Birmingham, England. Additional information may be obtained from British Information Services, 30 Rockefeller Plaza, New York 20, N. Y.

May 5-6—

American Society for Quality Control. Third annual convention to be



Double the Rod Size—

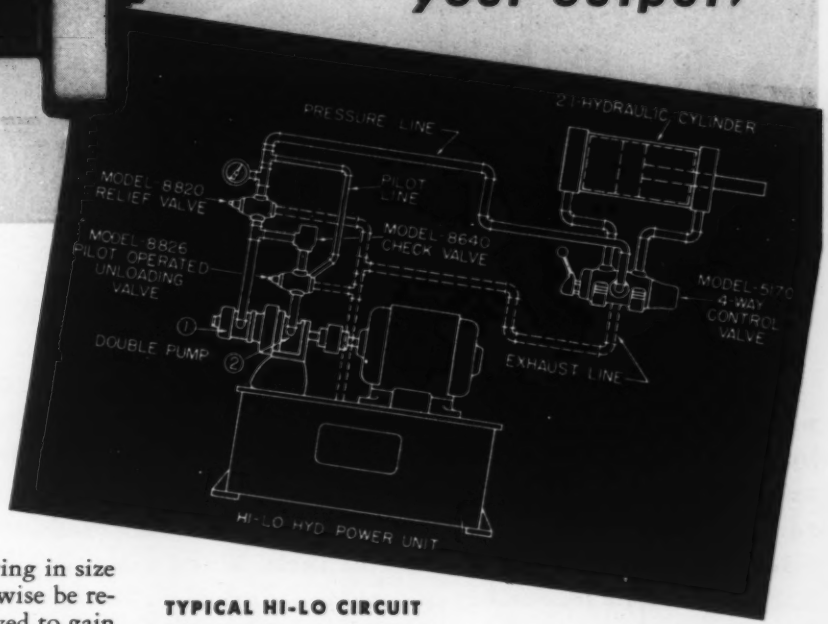
and increase your output!

GEROTOR 1500 P.S.I. HYDRAULIC 2:1 CYLINDERS have a piston rod about twice as large as standard cylinder rod size. The larger rod reduces oil displacement, permitting it to retract at twice the speed that it extends. This speed-up shortens cycle time, allowing the rod to extend again quickly, thereby accomplishing more work!

This faster speed is gained with a saving in size of motor and pump which would otherwise be required. 2:1 cylinders may also be employed to gain identical retracting and extending speeds, as well as to support larger loads where straight linear motion is used.

Available in 6 standard mountings: Foot, Trunnion, Center Line, Blind End Flange, Rod End Flange, and Clevis; in 10 bore diameters; in any stroke up to 96"; and with cushioning.

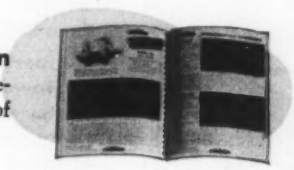
Remember—Gerotor Hydraulic Cylinders have Keeper ring design, permitting the cylinder to be rotated to convenient pipe connection.



TYPICAL HI-LO CIRCUIT FOR HYDRAULIC PRESSES

This circuit illustrates a press application where rapid speed and low pressures are required for the major portion of the stroke and high pressures are required for the "squeeze" portion of the stroke. The output of both the low pressure high volume pump (2) and the high pressure small volume pump (1) is directed to the hydraulic cylinder at a low operating pressure. When sufficient work load builds up, pressure in the system increases and the model 8826 pilot operated unloading valve unloads the output of pump (2) while the output of pump (1) is still directed to the cylinder. Direction of piston travel is controlled by model 5170 4-Way control valve. The horsepower requirement for this type of circuit is much less than if a single pump of sufficient volume and pressure for the application were used.

Send for Catalog Section No. 103 illustrating and describing all types and sizes of Gerotor Hydraulic Cylinders.



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WHEN YOU APPLY HYDRAULIC OR AIR POWER *Plan with* **GEROTOR**

AIR AND HYDRAULIC VALVES AND CYLINDERS, HYDRAULIC PUMPS, MOTORS AND PUMP UNITS

held at the Copley Plaza Hotel, Boston, Mass. Simon Collier, 22 E. 40th St., New York 16, N. Y., is executive secretary.

May 10-13—

American Management Association. 18th annual national packaging exposition to be held in the Public Auditorium, Atlantic City, N. J. Henry J. Hawlett, 330 West 42nd St., New York, N. Y., is secretary.

May 12-13—

Instrument Society of America. Fourth Annual spring meeting to be held at the Royal York Hotel, Toronto, Canada. Richard Remback, 1117 Wolfendale St., Pittsburgh 12, Pa., is executive secretary.

May 30-June 10—

Canadian International Trade Fair to be held at Toronto, Canada. Additional information may be obtained from the Administrator, International Trade Fair, Exhibition Grounds, Toronto, Canada.

June 5-10—

Society of Automotive Engineers. Summer meeting to be held at French Lick Springs Hotel, French Lick, Ind. John A. C. Warner, 20 West 39th St., New York 18, N. Y., is secretary and general manager.

June 6-8—

American Gear Manufacturers Association. 33rd annual meeting to be held at the Homestead, Hot Springs, Va. Newbold C. Goin, Empire Bldg., Pittsburgh 22, Pa., is executive secretary.

June 20-23—

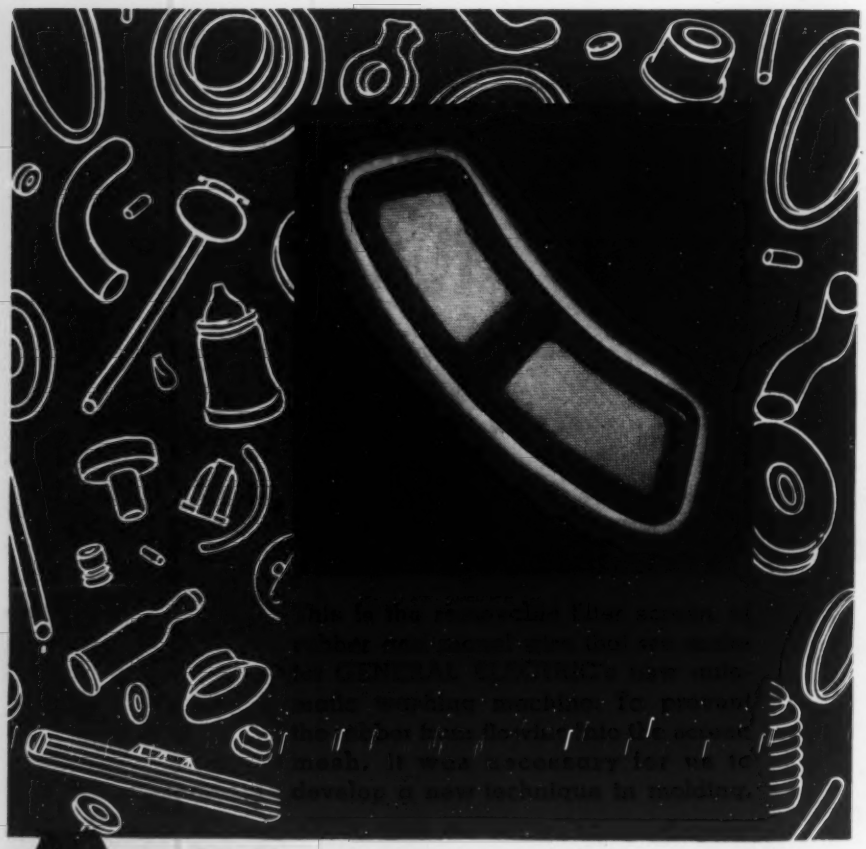
American Society of Agricultural Engineers. Annual meeting to be held at Michigan State College, East Lansing, Mich. Additional information may be obtained from society headquarters, P. O. Box 229, St. Joseph, Michigan. Raymond Olney is secretary.

June 20-24—

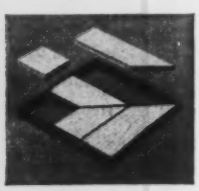
American Institute of Electrical Engineers. Summer general meeting to be held at New Ocean House, Swampscott, Mass. H. H. Henline, 33 West 39th St., New York 18, N. Y., is secretary.

June 20-24—

American Society for Engineering Education. Annual meeting to be held at Rennselaer Polytechnic Institute, Troy, N. Y. Prof. Arthur B. Bronwell, Northwestern University, Evanston, Ill., is secretary.

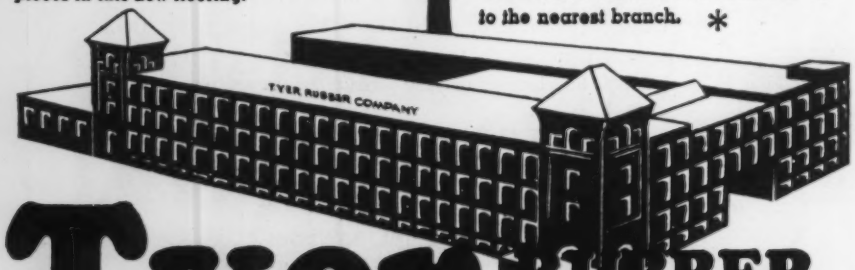


Tyer has been doing things with rubber for ninety-two years and during that time has made many contributions to the art. In earlier days Tyer originated white rubber and elastic webbing. During the late war Tyer's contributions ranged from giant rubber pontons to tiny ear plugs made to a tolerance of one thousandth of an inch. Since the war Tyer has resumed its leadership in service to industry. Many of the country's finest and most famous products have at one or more vital points a rubber part made by Tyer. These manufacturers know that Tyer can do unusual things with rubber.



Working closely with the inventor, REGENT PARQUET CORP., we developed the thin rubber frame that separates and holds the wooden pieces in this new flooring.

If there is a rubber part in your product (old, new, or proposed) Tyer technicians will give you the utmost cooperation in putting all our experience at your service. Ask the Tyer representative. Write to us in Andover or to the nearest branch. *



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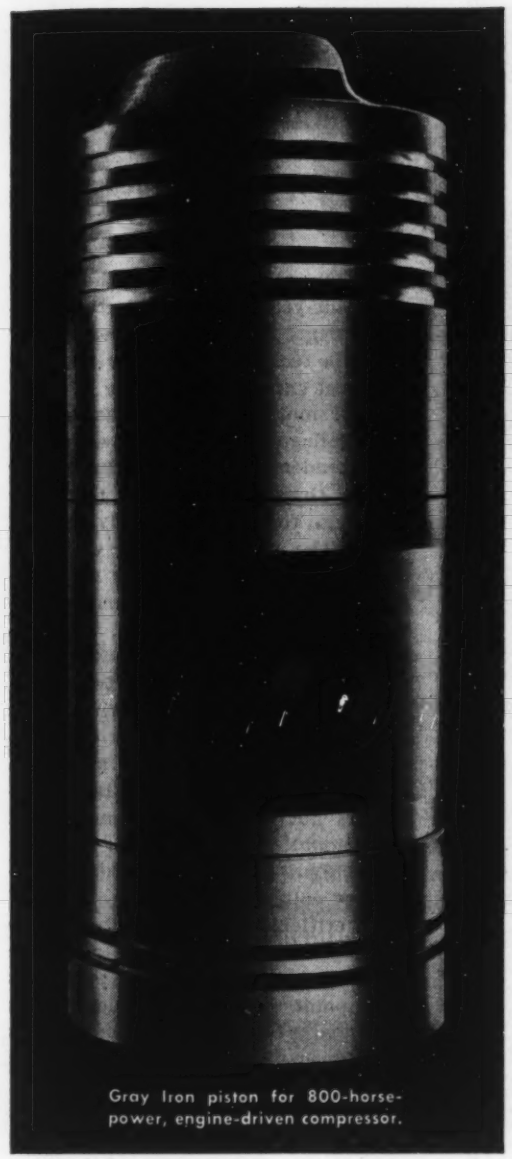

Gray Iron piston for 800-horse-power, engine-driven compressor.

"it wears like iron"...

TRUE... OR FALSE?

When you want to express the superlative in wearing quality, you will very probably say, "It wears like iron!" As a matter of fact, the statement is usually a grossly exaggerated one, for *nothing* wears like iron *except iron.*

Note the general use of gray iron castings for moving parts such as gears, sprockets, machine tools, engine cylinders, piston rings, brake drums . . . that is your best evidence of gray iron's wear-resistant qualities.

Wherever sliding friction, galling or wear are serious factors, especially in the presence of heat, Gray Iron does an outstanding job. It gives you an unmatched combination of useful properties . . . *plus ultimate economy.*

Send for free booklet "GRAY IRON—Its Mechanical and Engineering Characteristics, and Details for Designing Cast Components".

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Gray Iron Characteristics Include:

- **Castability**
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- **Wide Strength Range**

GRAY IRON FOUNDERS' SOCIETY, INC.

NATIONAL CITY BANK BLDG. CLEVELAND 14, OHIO

Announcing A New LOW COST Ball Bearing for Your

LINEAR MOTIONS

BALL BUSHING

THE COMMERCIAL GRADE SERIES B

Sliding linear motions are nearly always troublesome. Thousands of progressive engineers have solved this problem by application of the Precision Series A Ball Bushing.

The low-cost Commercial Grade Series B bearing is now added to the Ball Bushing line and offered to original equipment manufacturers. This ball bearing has been developed for support of linear motions in competitively priced, volume produced products where super precision is not essential. Alert designers can now make tremendous improvements in their products by using Ball Bushings on guide rods, reciprocating shafts, push-pull actions, or for support of any mechanism that is moved or shifted in a straight line.

Competition is returning. Up-to-date engineering can be *important to you!*

- LOW FRICTION
- ELIMINATE BINDING AND CHATTER
- SOLVES SLIDING LUBRICATION PROBLEMS
- LASTING ALIGNMENT
- LOW MAINTENANCE
- LONG LIFE

NOW AVAILABLE for ¼", ½", ¾" and 1" shaft diameters. Additional sizes to follow. Write for new literature covering both the Series A and Series B Ball Bushings and the name of our representative in your city. No obligation.

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PROGRESSIVE MANUFACTURERS USE BALL BUSHINGS — A MAJOR IMPROVEMENT AT A MINOR COST

Design Abstracts

Co-operative Graduate Education

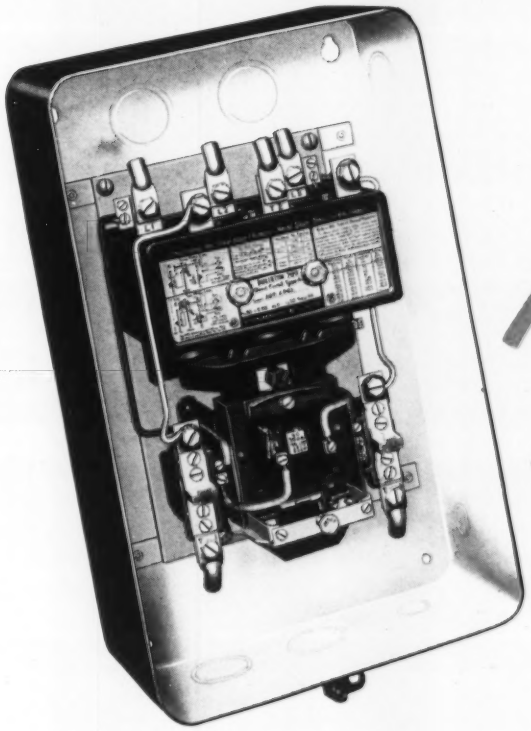
UPON completion of the usual four-year program for the bachelor's degree, a large percentage of students feel the immediate need for practical experience in spite of a desire for more advanced training. In fact, college professors often advise their students to enter industry for two or three years before returning to college for graduate study. In that period, the young engineer or scientist frequently accumulates responsibilities that make his return to college financially impractical. He also finds an opportunity for usefulness in industry that he is loath to terminate. Graduate study on a part-time basis arranged concurrently with early industrial experience not only meets the need of these young scientists and engineers but is often a richer overall educational experience for many minds than further full-time attendance at college.

In criticizing these plans, those who oppose granting full academic credit for courses in such programs often point out that the student does not have access to the laboratories and libraries of the college when courses are conducted off-campus. If, however, the program is arranged in full co-operation with the industrial company, the laboratories of the company become an equally good training ground as that of the college laboratories, and in some cases may be far better because of the ability of industry to provide more adequate laboratory facilities in specialized fields than can any college or university. So far as library work is concerned, it must be realized that graduate work is largely specialized, and that reference material is largely limited to special fields. In these special fields, the libraries established by industrial companies for the use of their engineers and scientists may readily be fully the equal of the college libraries in these same fields. If not, this difficulty can be remedied to a degree comparable with that of many institutions by a relatively small outlay for additional library facilities.

If such courses as these are to be recognized as worthy of graduate credit, it seems that the most important element is the selection of

(*Continued on on Page* 245)

The Motor Starter for THOUSANDS of APPLICATIONS



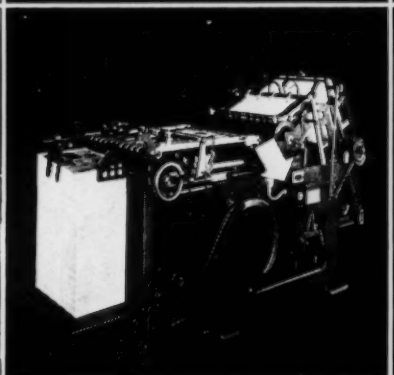
. . . Good for Millions of Trouble-Free Operations

VERSATILE . . . that one word best describes the wide utility of the Allen-Bradley Bulletin 709 Solenoid Starter. Most motor installations need across-the-line starting . . . push-button control . . . and dependable overload protection. These features . . . and many more . . . are provided by all Bulletin 709 Solenoid Starters.

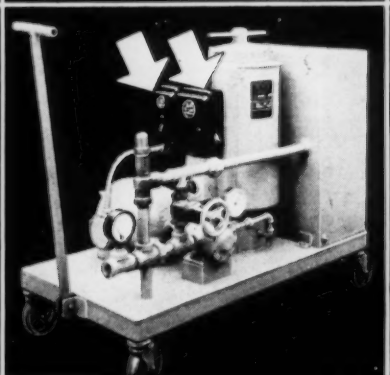
TROUBLE-FREE . . . that one word sums up the year-after-year service of Bulletin 709 Solenoid Starters. Only one moving part . . . hence no tricky gadgets to corrode, stick, or break. No contact maintenance. Install the Bulletin 709 Starter and forget it. It's good for millions of trouble-free operations.

for MOBILE MOTORS

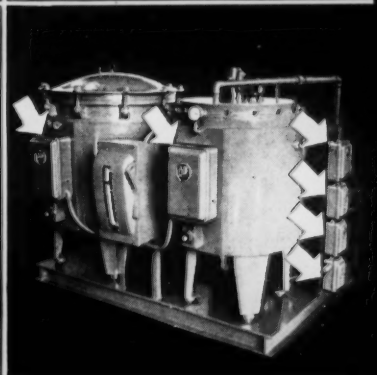
for PRINTING MACHINERY



for PAINT SPRAYERS

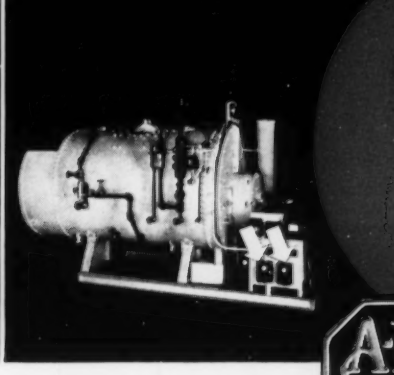


for OIL CONDITIONERS



for FLASH WELDERS

for STEAM GENERATORS



ALLEN-BRADLEY

QUALITY

MOTOR CONTROL

A-B Quality

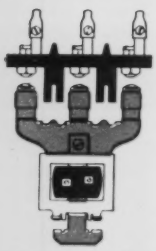
Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wisconsin

Let us send you this CONDENSED CATALOG

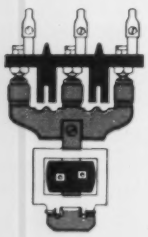
ALLEN-BRADLEY CONTROLS

Bulletin 709 Solenoid Starters . . . made in six sizes . . . up to 200 hp, 440-600 v.

Only ONE Moving Part



The 3 moving contacts, cross-bar, and solenoid plunger (shown in red) form a single unit, which moves UP and DOWN in the solenoid coil with a simple, straight-line motion.



The 3 double-break, stationary contacts in the arc hood, to main line and motor, are "bridged" or closed by the moving contacts when the solenoid plunger is UP as shown above.

This compact Allen-Bradley catalog is a quick-and-easy reference manual on the performance, dimensions, and prices of starters, contactors, relays, push buttons, limit switches, etc., that exactly fit your needs.

Allen-Bradley solenoid motor controls are preferred by leading machinery manufacturers. Why? Because the simple design . . . ONLY ONE MOVING PART . . . means no pins, pivots, hinges, bearings, or other troublemaking parts. And their double-break, silver-alloy contacts need no maintenance. Write for catalog, today.

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THERE IS A STANDARD A-B ENCLOSURE FOR EVERY INDUSTRIAL NEED

General Purpose | Dust-tight | Water-tight | Hazardous Dust | Hazardous Gas | Non-Haz. Cor. Gas | Haz. Corrosive Gas

A-B Quality

ALLEN-BRADLEY

SOLENOID STARTERS

QUALITY

(*Continued from Page 242*)

the teachers who will handle these courses, to make sure that they have the desired attitude, and that the courses are conducted along suitable lines. Insofar as possible, it is of course desirable that the same staff teach these courses when given off-campus that teach the same or similar courses when given on the campus. When this is done, and when suitable laboratory and library facilities are available, certainly such courses will not differ greatly from campus courses, and will on the average be no better or no worse than the corresponding campus courses. In all cases, it is not possible to utilize regular campus professors for all courses in such programs, and in these cases the choice of the best instructor involves a careful consideration of the training and educational experience, as well as the attitude, of the instructor selected. However, with suitable care and supervison, instruction fully worthy of graduate college credit can be and should be obtained.

Experienced Instructors Needed

In every such program, however, a substantial percentage of instructors should be regular members of the college faculty who travel to the off-campus locations to give these courses, to advise students, and to consult with students regarding possible research programs which may be undertaken for research credit and the development of a possible thesis. When these safeguards are maintained, off-campus programs of this sort can be conducted at the true graduate level, and there should be no hesitancy in giving full graduate credit for them. In any case, whatever difficulties may arise, the same difficulties are present on the campus, although to perhaps a slightly lesser degree. When both industry and the colleges are aware of the problems, and approach them together, the problems can be fully surmounted, and adequate educational programs can be developed which bring to industry educational opportunities that would not otherwise be possible. — *From a paper presented by W. A. Lewis, dean, graduate school, Illinois Institute of Technology, at the Winter meeting of AIEE in New York.*

O-Ring Friction Characteristics

AMONG the small but important parts of a hydraulic system are the packings. Earlier systems in use for aircraft employed one or more of the well-known V-ring, U-cup, or

FREE
-TO GEAR BUYERS

FREE THIS HANDY GEAR TOOTH CALCULATOR

The numbers on the outer edge of this device represent the diametral pitch of the gear. By turning the cut-out section to the desired number, the figures appearing in the space show circular pitch, circular thickness, addendum and the whole depth. • These calculators are available to gear buyers upon request—with our compliments.

YOU FURNISH THE SPECIFICATIONS • WE'LL PRODUCE THE GEARS

PERKINS Precision, Custom-Cut GEARS

PERKINS MACHINE & GEAR CO., Springfield 2, Mass.

A "NEW" SMALL REVERSING CONTACTOR

. . . a result of three years experience in actual service

for Continuous Duty Control
OF EITHER AC OR DC EQUIPMENT

Ideal for "Built-in" applications . . . Completely serviceable from the front

THE FIRST small reversing contactor, introduced by Struthers-Dunn over 3 years ago, represented a big improvement over existing methods of controlling hoists, door operators and similar equipment. The design of this new contactor, Type 175KXX is based on broad experience in applying the original unit and incorporates still further advantages including greater ruggedness and the ability to withstand continuous service. Ratings are as follows:

AC single phase: 1 hp. 115 or 230 volts
AC polyphase: 2 hp. 110 or 220 volts
1 hp. 440 or 550 volts
Direct current: 1 hp. 115 or 230 volts

Two 3-pole solenoids, for forward and reverse operation, are mounted on a common frame and mechanically interlocked to prevent simultaneous closure. Contacts are completely insulated with melamine. Open arc chutes allow rapid cooling and escape of ionized gases.

Auxiliary contacts can be added for electric lock-up or interlock. All fixed contacts are interchangeable as are the moving contacts and corresponding parts on each solenoid. All parts are easily replaceable from the front.

Write for Data Bulletin 7100.

STRUTHERS-DUNN

Struthers-Dunn, Inc., 150 N. 13th St., Philadelphia 7, Pa.

ATLANTA • BALTIMORE • BOSTON • BUFFALO • ROCHESTER • CHARLOTTE
CHICAGO • CINCINNATI • CLEVELAND • DALLAS • DENVER • DETROIT
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compression-type packings. The O-ring is a fairly recent development in the packing field, which has been shown to have many advantages over the older types.

To prevent sticking of moving parts and excessive wear on packings, the friction between the moving parts and the packing should be held to a minimum. It would be expected that the early compression-type packings would cause high friction because of their design. O-rings offer an opportunity to reduce this friction because of a much smaller area of contact with the moving part.

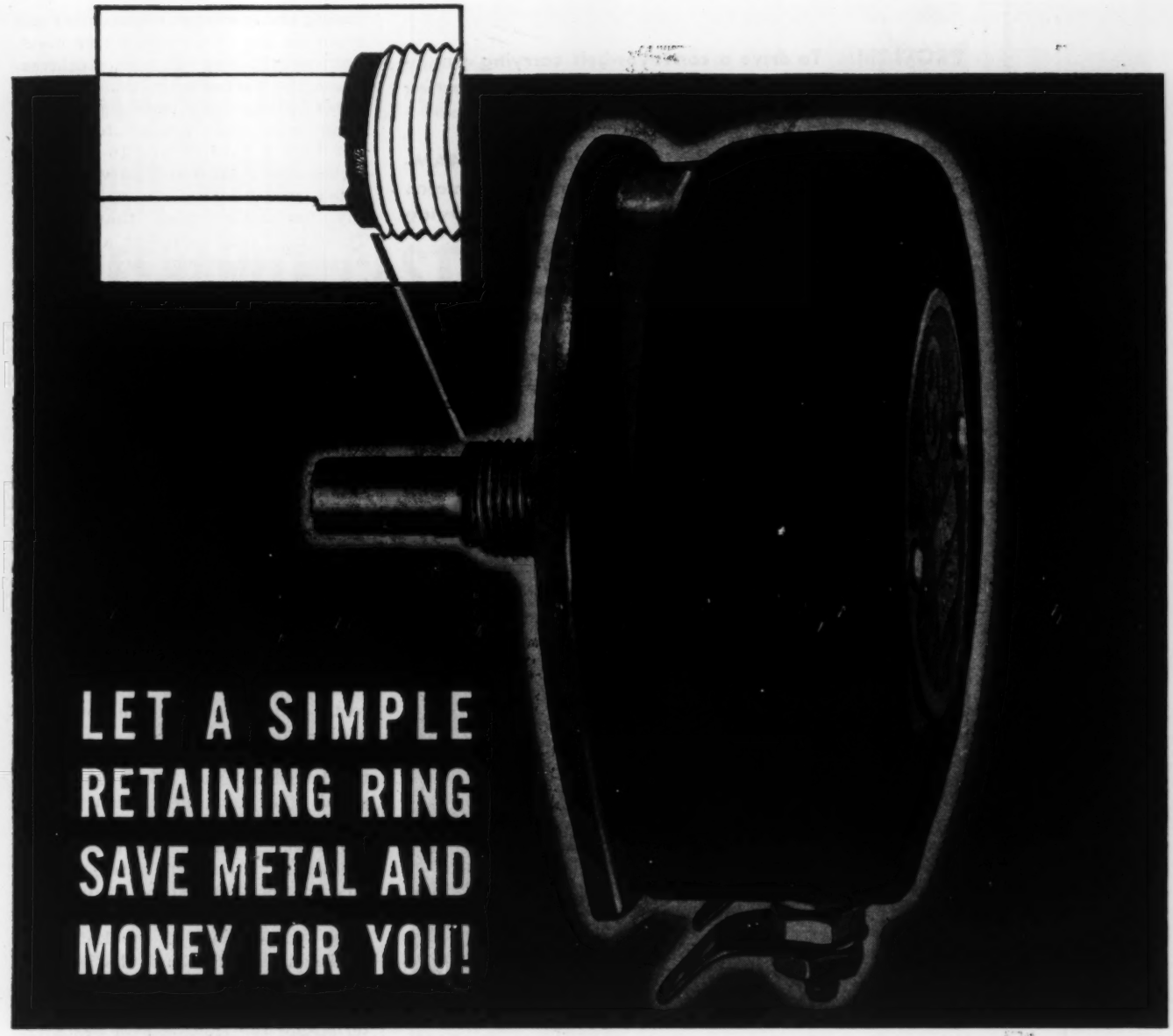
An apparatus was designed so that friction caused by an O-ring could be measured under controlled conditions, with one factor varied at a time. In the apparatus employed, an actuating rod was drawn through a stationary O-ring. Frictional forces were transmitted from the ring, through a bellows arrangement, to a recording engine indicator.

Breakout and running friction determinations were made under various conditions of pressure and time delay, in addition to variation of squeeze. The result of a large number of tests shows that the running friction is largely independent of squeeze over the range covered. There is some tendency at higher pressures for the running friction to increase slightly with squeeze. A different situation exists in the case of breakout friction, where an increase in squeeze results in an increase in friction.

Effects of Pressure

There is a strong trend toward higher pressures in the newer aircraft systems, and the effects of 500, 1000, and 1500-psi pressure were checked in this study. It was found that an increase in pressure resulted in a small increase in running friction and a large increase in breakout friction. It has been generally felt that the breakout friction would be higher as time delay between strokes increased. Experimental results confirmed the original belief for time delays of less than 40 minutes. Time delays of more than 40 minutes, however, did not appreciably increase the friction.

Running friction was not expected to change with time delay between strokes. In this case also, the experimental data confirmed the original belief. The importance of roughness of the surface which rubs against the ring has been recognized by other investigators. Army - Navy specification AN-P-74 requires a surface finish (roughness) of 5-15 microinches rms. (This is to be changed by elim-



LET A SIMPLE RETAINING RING SAVE METAL AND MONEY FOR YOU!

On this finely made rheostat retaining rings saved material and assembly time. They save money both for Hardwick Hindle, the manufacturer, and for its customers.

Looking at this application you may say it was obviously a "natural," but there are literally thousands of cases where retaining rings can save as much or more.

Examine your machines and products to see where the use of these inexpensive modern artificial shoulders can cut your costs.

It's needlessly expensive to hold a mechanism in place with unnecessarily big shoulders or collars, or to temporize with small cotter pins etc., etc.

Let us show you how these high grade steel rings can do a thoroughly efficient job, saving money for you and for your customers.

More and more applications of retaining rings are being made every day.

Write today for descriptive folder.

THE NATIONAL LOCK WASHER CO.

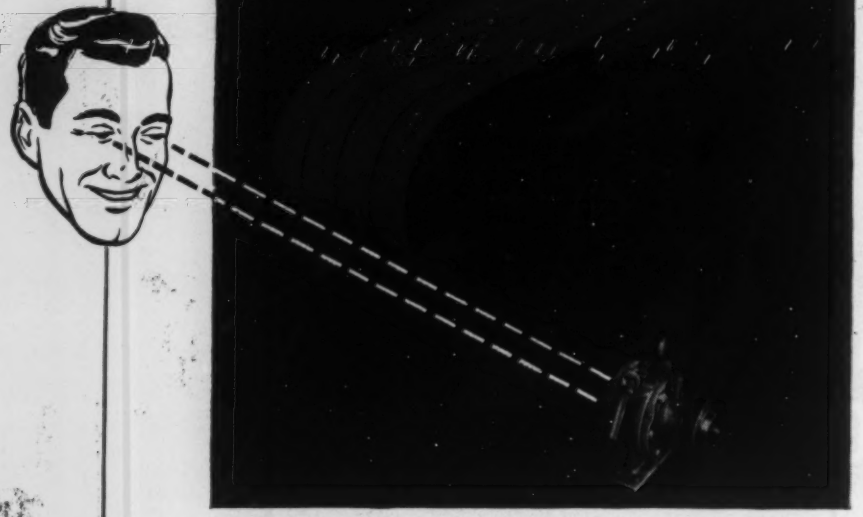
NEWARK 5, NEW JERSEY • MILWAUKEE 2, WISCONSIN, U. S. A.

PROBLEM To drive a conveyor-belt carrying fragile material and provide automatic belt-speed reduction when drag of load increases.

SOLUTION A 1 h.p. Gast Air Motor (Model 4AM-FCC-1) connected to plant compressed air line. Maintains constant tension on material in process despite varying load-drag and belt r.p.m.

RESULT This successful, variable-speed drive reduced material spoilage on this machine—and saved money.

UNUSUAL CONVEYOR-BELT PROBLEM solved with a variable-speed GAST AIR MOTOR



USED FOR MANY APPLICATIONS—From this case history, you can see how Gast Rotary Air Motors solve some unique power problems. As original components on products in *totally different fields,* they offer unmatched advantages. For example:

AIR MOTORS CAN'T BURN OUT—It's possible to stall them but pneumatic motors can't burn out!

CAN'T SPARK EXPLOSIONS—No spark, no danger—Gast Motors are explosion-proof anywhere.

GIVE YOU VARIABLE R.P.M.—From any position, they start and run at 100 to 2,000—some to 6,000 r.p.m.

THEY'RE AMAZINGLY COMPACT—The 1/6 h.p. motor is only 2½" diameter; 1 h.p. is 6-3/8" x 6" high (with foot.)

AND COST IS LOW—Ruggedly built, they offer unique advantages—and cost less! Why not investigate now? We'll gladly cooperate with engineering help.

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(TO ONE H.P.) (TO 30 LBS.) (TO 28 INCHES)
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inating the minimum requirement and retaining the 15-microinch rms maximum roughness.) In order to investigate this factor more thoroughly, a series of four rods was constructed. These rods were ground to finishes of 2.8-3.2, 6-8, 10-12, and 16-18 microinches rms. All four rods were evaluated with the same ring to eliminate any variability from that source. These four rods represent a range of surface finishes not only covering, but also above and below the present specification limits. The tests show that there is a definite increase in friction with increase in surface roughness.

It has been reported that a chemical surface treatment was being used on some hydraulic parts. Several advantages were claimed for this treatment, particularly reduction of friction because of better retention of an oil film on the surface. In order to investigate this point, a special rod was constructed and treated by a commercial process. This rod had a surface finish of 10 microinches rms before treatment and 30 microinches rms after treatment. The frictional results obtained were apparently directly proportional to the roughness of the finished rod.

A limited amount of work was done to determine the effect of stroke speed. The running friction was almost independent of stroke speed over the range tested. An increase in breakout friction was noted with an increase in stroke speed at 1000 psi, but at other pressures the friction was independent of stroke speed. There are indications that factors other than stroke speed, for example pressure, are more significant in determining the friction in a system.—*From a paper by L. E. Cheyney, W. J. Mueller and R. E. Duval, Battelle Memorial Institute, presented at the annual meeting of ASME in New York.*

Color in Aircraft

COLOR has a profound psychological effect, and nowhere more so than in airplanes. The airplane is a light vehicle which flies, and its habitat is the sky. If these facts are allowed to set the keynote for interior color schemes, the effect on passengers will be most pleasing, satisfying and reassuring.

On this theory, the entire fuselage lining, from the dado up, should be high in key, clean and clear but neutral in color. For practical as well as aesthetic reasons, dado and seats should be in deeper, cleaner but harmonizing tones, and in the in-

MOORE JIG BORER built with MEEHANITE® CASTINGS for...

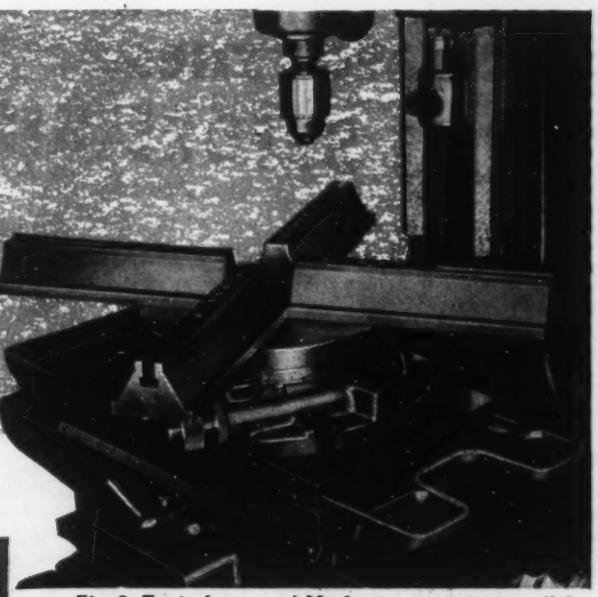

Fig. 2. Typical set-up of Meehanite extension parallels.

"Control of Hardness"

"Uniform Grain"

"High Strength"

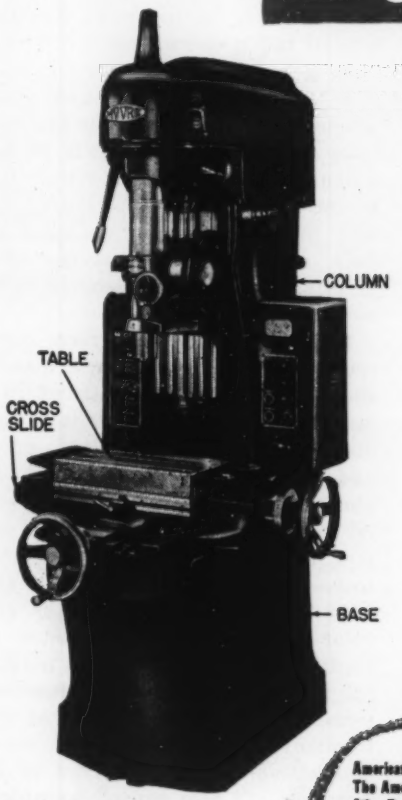

Fig. 1. Important Meehanite castings used in the construction of the Moore No. 2 Jig Borer.

The precision jig borer illustrated (Fig. 1), manufactured by the Moore Special Tool Co., Inc., Bridgeport, Connecticut, uses Meehanite castings extensively because of their contribution to the quality, accuracy and precision operation of this machine tool.

The important castings indicated are, according to the chief engineer of the company, specified as Meehanite castings for the following reasons:

1. "Close control of hardness for maximum wear resistance, yet just within the range of hand scraping."
2. "Uniform close grain for good machinability and absence of blow holes."
3. "High tensile strength and resistance to deflection."

In addition a number of fixtures similar to the extension parallels (Fig. 2) are Meehanite castings for similar reasons.

Complete machining data for various types of Meehanite castings is tabulated and illustrated in our new Bulletin No. 29 "How to Machine Meehanite Castings." For a copy write to any of the foundries listed.

MEEHANITE FOUNDRIES

American Brake Shoe Co.	Mahwah, New Jersey	Koehring Co.	Milwaukee, Wisconsin
The American Laundry Machinery Co.	Rochester, New York	Lincoln Foundry Corp.	Los Angeles, California
Atlas Foundry Co.	Detroit, Michigan	The Henry Perkins Co.	Bridgewater, Massachusetts
Banner Iron Works	St. Louis, Missouri	Pohlman Foundry Co., Inc.	Buffalo, New York
Barnett Foundry & Machine Co.	Irvington, New Jersey	Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
H. W. Butterworth & Sons Co.	Bethayres, Pennsylvania	Ross-Meehan Foundries	Chattanooga, Tennessee
Continental Gin Co.	Birmingham, Alabama	Shenango-Penn Mold Co.	Dover, Ohio
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.	Smith Industries, Inc.	Indianapolis, Indiana
Crawford & Doherty Foundry Co.	Portland, Oregon	Standard Foundry Co.	Worcester, Massachusetts
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut	The Stearns-Roger Manufacturing Co.	Denver, Colorado
Florence Pipe Foundry & Machine Co.	Florence, New Jersey	Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio	U. S. Challenge Co.	Centerville, Iowa and Batavia, Illinois
General Foundry & Manufacturing Co.	Flint, Michigan	Valley Iron Works, Inc.	St. Paul, Minnesota
Greenlee Foundry Co.	Chicago, Illinois	Vulcan Foundry Co.	Oakland, California
The Hamilton Foundry & Machine Co.	Hamilton, Ohio	Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey
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terest of simplicity I prefer to have dado and seat covering a fairly close match. Floor covering should be a still deeper tone in the same harmonious scale, so that the weight of color increases downward and reaches its maximum at the floor. This arrangement, which may be called gravitational, gives a sense of stability, and is the same scheme which nature displays normally in sky, horizon and landscape.

I prefer to keep all these major tones on one side of the spectrum, that is in the cool range or in the warm. But generally the cool side is to be preferred in planes—light cool tones contrast in a less unfriendly way with what one sees through the windows of the plane, and are more restful because they require less eye accommodation. Nature, you know, at least over most of the earth's surface, uses only cool colors in large areas and reserves bright, but hot colors for smaller accents. In the same way one can move to the other side of the spectrum for complimentary or contrasting accents to relieve and accentuate the major color scheme; thus, in a cool blue and light gray scheme, minor accents of vermilion, salmon, or clear yellow may be introduced in the pattern of curtain materials, piping or other details, and they will have the effect of bringing the whole scheme to life and making it sing.

It is axiomatic that green, chartreuse, and yellow (in large masses) should be avoided as contributory to air sickness, but I have an equal dislike for raspberry reds, blue greens and purplish blues—at least in airplanes. They may be mated correctly, according to Mr. Munsell's system, but in practice they may prove to be extraordinarily bilious. In fact, I do not believe that a really good color scheme can be concocted according to any "system." It must be the product of a sure, individual color sense which follows the rules of color harmony unconsciously but surely, and without being hampered by any formula.—*From a paper presented by Walter Dorwin Teague at the recent annual SAE meeting in Detroit.*

Crane Cabs Improved

IN ADDITION to the machine he is operating, a crane operator is really boss of everything that goes on below him, and if he isn't on his toes he can soon destroy a lot of property. He can also destroy lives. In a lot of places where cranes are a part of the production scheme, a slow-down on his part means a slow-down in

New and Improved VICKERS PRODUCTS

For Better Hydraulic Machinery

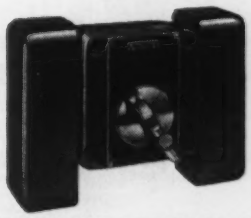
The Vickers units illustrated below are either new products or have recently been improved. Among their advantages are small size, and many have gasket mounting for even more compact hydraulic installations. For information regarding any of these new or improved units, ask for the Data Sheet or Bulletin number indicated.

VICKERS CHECK VALVE (In-Line Type)

For working pressures up to 3000 psi, this compact check valve can be furnished for piping sizes ¼", ¾" and 1½". Data Sheet 113720.

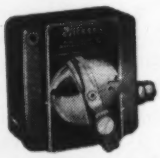
VICKERS FLOW CONTROL VALVE

Accurate control of oil flow in hydraulic systems (independent of pressure variation) can be obtained with this compact, gasket mounted unit. Bulletin 45-35.



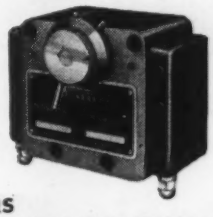
VICKERS CYCLE CONTROL PANEL (Solenoid Operated)

A compact unit for controlling rapid traverse and adjustable feed cycles with fully remote electrical cycle timing. Data Sheet 109164.



VICKERS FLOW CONTROL AND OVERLOAD RELIEF VALVE

Compact metering valve incorporates the Vickers patented flow control and relief valve for regulation of oil flow and pressure. Bulletin 48-36.

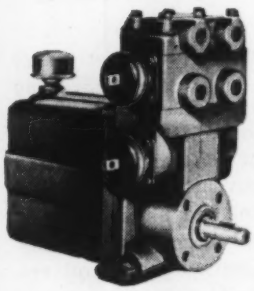


VICKERS RECIPROCATING CYCLE PANEL

For reciprocating cycles of machine tool carriages, etc., with accurate and selective reversal control. Data Sheet 80803.

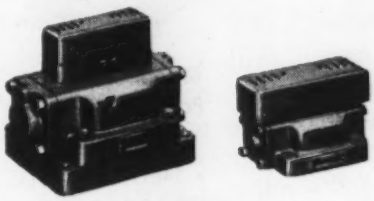
VICKERS PRESSURE SWITCH

Available in two models for pressure ranges 100-2000 and 500-3500 psi with independent pressure differential adjustment. Data Sheet 113929.



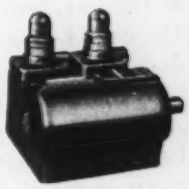
VICKERS POWER PACK

Vane type hydraulic pump, overload relief valve, oil tank, filter and operating valve are included in this low priced unit. Bulletin 46-48a.



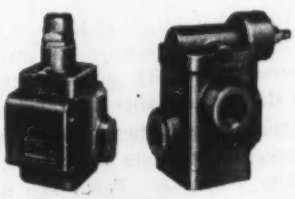
VICKERS SOLENOID OPERATED CONTROL VALVES

Compactness, simplified installation and minimum piping are but a few of many features. Bulletin 48-27.



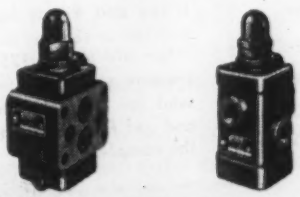
VICKERS TWO PRESSURE PUMP (Small)

Two vane type pumps and integral automatic valving, all combined in this compact unit, providing high-low pressure pumping action. Data Sheet 117994.



VICKERS PRESSURE REDUCING VALVES

Maintain accurate reduced pressure; available with integral free return flow check valve, gasket and screw connections. Data Sheets 101885, 100165.



VICKERS PRESSURE SEQUENCE CONTROL VALVES

These new sequence valves are available for smaller piping sizes, and are arranged either for gasket mounting or threaded-connections. Bulletin 45-34a.

VICKERS PROPORTIONAL OIL FILTER

This compact filter provides continuous micronic filtering for hydraulic systems at pressures up to 3000 psi. Bulletin 47-30.

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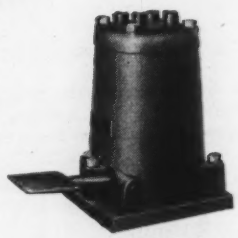

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The 3401-RA4 pictured above is a 4-way two position valve for controlling double acting air cylinders. Ideally used with brakes, shears, presses, forging machines, etc., because the operator has both hands free to handle the work. Furnished in 3/8", 1/2", 3/4", 1", 1 1/4" and 1 1/2" sizes. 3-way and 4-way neutral position or regular actions—for air up to 125 lbs. pressure and 150° F.;—but send for a catalog today and get *full* details about the *complete* line.

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production. Thus, it is important that a crane operator be alert at all times.

Recent trends in improving working conditions for crane operators have resulted in such changes as making the front of the cab circular, protecting the bottom of the cab with a heavy channel to reduce the dangers from swinging loads, enclosing and air conditioning the cab from severe weather conditions, and providing for operation of the crane from a sitting position whenever possible. We are recommending that control equipment for smaller cranes be made smaller to keep the cab size relatively small. Another recent improvement has been the location of master switches at the rear of the crane and the controls in front of the operator so that as he swings in his chair, the controllers swing with him. Of course, there are some installations where this scheme won't be practiced—for example, on a seven-motor crane—but ninety per cent of the cranes built are either three or four motors, so we'll not worry too much about those having more than four motors.—*From a paper presented by E. C. Rice, vice president, Whiting Corp. at the Materials Handling Machinery Manufacturers' Conference at Westinghouse Electric Corp., Buffalo.*

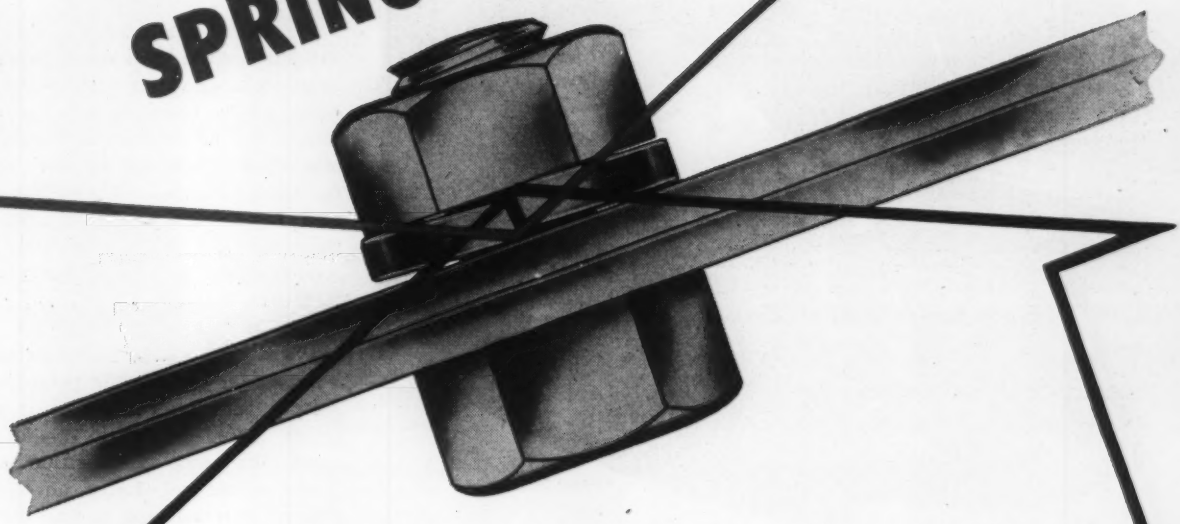
Better Engine Oils Needed

BOTH automotive and petroleum industries need more engine service tests to produce better quality crankcase oils. It is apparent that "quality" of oils cannot be measured by the conventional laboratory tests for chemical and physical properties even though it may be possible to determine if an unknown oil resembles another oil whose performance in service is known.

The way to determine whether an apple is good to eat is to eat it. The way to find if an oil is good is to use it in an engine, because the only real measure of quality of a lubricating oil is its performance in service. At the present time there are no generally recognized tests to evaluate oils in many respects. Tests are needed to determine:

1. Ability of oil to decrease wear of engine parts in light or intermediate service
2. Effect of oil on the formation of combustion chamber deposits which may affect the antiknock requirements of the engine
3. Effect of oil on exhaust-valve burning

CONCENTRATED SPRING POWER



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Reliance Spring Lock Washers offer a dependable method of keeping bolted assemblies tight.

Their helical coil spring design, when compressed, builds up a powerful mechanical reactive pressure between nut or bolt head and the bolted surface. By maintaining bolt tension, this reactive pressure keeps nut or bolt from turning where thread fits are not tight and also automatically compensates for looseness resulting from service wear. Reliance Spring Lock Washers are available with a reactive range adequate to meet every service need.

Reliance Spring Lock Washers also act as hardened thrust bearings, reduce surface resistance and permit greater tightening torque.

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RELIANCE RINGS—provide strong, heat treated shoulders on shafts or in counter-bores, lock assemblies securely. On in a jiffy, off in a jiffy, they speed production, cut costs. Write for Reliance Ring folder.

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Perhaps the machines you use, or the products you make, can be improved through the use of Electrol hydraulic devices. The Electrol engineering staff will gladly work with yours on any specific application. Write for further details — or better still — let us arrange to have one of our engineers call at your convenience.

The Fairchild C-82 Packet employing the new, revolutionary track-type landing gear that enables aircraft to take-off and land on sod, sand or other unimproved surfaces. Working with Fairchild, Electrol engineers designed and built the Air Springs, which provide the tremendous force necessary to maintain tension in the built-in-runway's "belt"—yet, keep it flexible enough so that it will deflect when obstacles are encountered.

The Improved Paper Cutter built by E. P. Lawson Co. utilizes a newly developed automatic clamp and tip-toe treadle to assure higher accuracy in cutting, easier operation and less maintenance. To help perfect this device Electrol engineers were called upon to supply the required hydraulic units used in the system, including the actuating cylinders and valves.

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4. Effect of oil on the life of spark plugs
5. Rate of oil consumption as it is affected by the formation of deposits in the engine and by ring wear and cylinder wear due to corrosion.

We have come a long way since the time when we had to depend for lubricants on animal and vegetable oils, whose properties were determined by the manner in which these oils were produced by the animals for their own use. When the animals and vegetables produced these oils, they did not make any attempt to modify their properties so that they would be suitable for passenger cars, trucks or diesels.

When the early lubricating oils were made from crude petroleum we simply separated the oils from the crude petroleum, with the oils very much the same composition as produced in nature. Later, chemical engineers learned how to find out what the engines wanted and how to produce oils to meet the demands of the engine and how to evaluate these specially developed lubricants in many respects by means of actual engine tests. However, it is not enough to develop a process to make an oil of certain properties without also determining whether the oil is of that type that should be used.

Oil performance depends upon engine design, operating conditions, fuels and lubricants. Before the chemical engineer develops the process that should be used or before the refinery is designed, great care should be taken to insure that the best possible answer is obtained to the question raised by those four factors.— *From an address by H. C. Mougey, General Motors research laboratories, presented at Ohio State University Diamond Jubilee Celebration.*

Linestarting D-C Motors

THERE are many limitations and disadvantages to linestarting d-c motors which are imposed by the installation, and which have little bearing on the design or performance of the motor. The most important factor in determining whether a linestarted motor can be applied is the frequency of operation. If the frequency is low, most other factors become relatively unimportant and consideration need only be given to the motor itself. When the frequency is high, other factors need to be considered also.

Among those factors which limit the application of a linestarter to a

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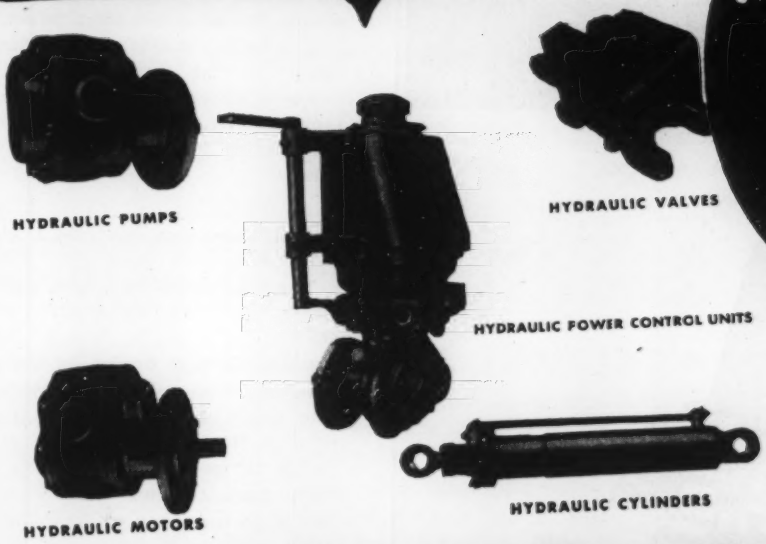

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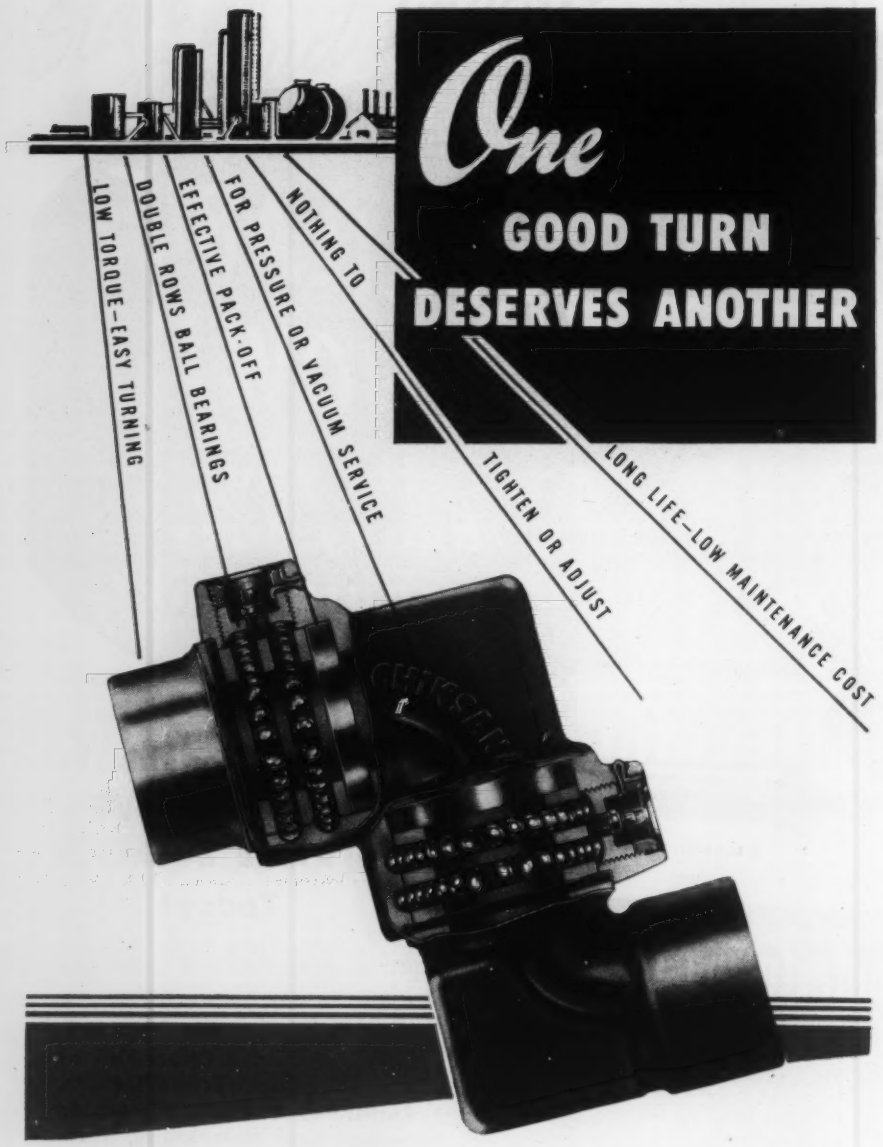

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WRITE FOR CATALOG NO. 48

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BALL-BEARING SWIVEL JOINTS FOR ALL PURPOSES

d-c motor is the type of circuit which is used to supply power for the motor. A d-c motor has relatively low resistance and inductance and consequently the starting current is very high. This means that the disturbance to the line is much greater in starting a d-c motor than for a corresponding size a-c motor. If the circuit is supplying lights, there may be some objection to a disturbance to the line, which will cause a blink of the lights when the motor is started across the line. In some cases, there are voltage-sensitive instruments or relays on the circuit and when the motor is linestarted, the voltage drops momentarily, and adversely affects the operation of these instruments or relays.

Influences of Driven Machine

The machine to be driven will sometimes limit the application of linestarted d-c motors. Due to the high starting current drawn by the motor, the torque developed is very high. The gears, belts and other components in the driven machine must be designed to withstand these sharp, high peak torques. In most cases this high torque is of very short duration and results in an impact blow, and it must be recognized and provided for. Since this starting and accelerating torque is large, some overshoot in speed is likely to occur. The driven machine must be such that momentary overshooting of speed is not objectionable. In some cases this overshoot of speed amounts to five per cent, varying with the size of the motor, the operating speed, and the type of winding used for the motor.

Motor Performance Factors

From the standpoint of motor performance, there are several limitations or factors which must be considered. One of the most important is sparking or flash-over at the commutator. Since the currents are high at linestarting, there is always some spit at the brushes. As the size of the motor increases, this action increases and very often sparking is so bad that a flash-over results. A flash-over, even occurring occasionally, must be avoided as it results in severe burning and often actually burns open the circuit. On the other hand, sparking, even though severe, usually will cause no permanent injury unless the motor starts a high-torque load or a high-inertia load. In normal service, the developed torque is so great that the motor quickly comes up to speed and the duration

Haskelite Materials

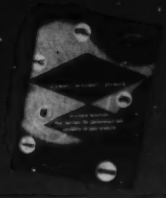
OPEN NEW HORIZONS IN PRODUCT DESIGN

Designers and manufacturers find the unique characteristics of Haskelite Structural Materials offer many advantages over wood, metal or other materials they are replacing in so many products . . . and find they help build products that look better, perform better and sell faster.

SALES BUILDING APPEARANCE: In the group of Haskelite Materials, are lightweight metal faced plywoods with smooth, ripple-free surfaces . . . metal backed veneers of beautiful woods that may be fabricated as easily as sheet metal . . . any one will help add new eye appeal to your products.

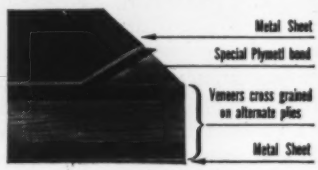
LIGHT WEIGHT — GREAT STRENGTH: The rigid *strength-to-weight* ratios of certain Haskelite Materials are unmatched by even the newest of light alloys.

SIMPLIFIED CONSTRUCTION: Haskelite materials are worked with simple tools. Their use often eliminates numerous or complicated framing members — cutting deadweight and saving time. Write for bulletin SC-47.



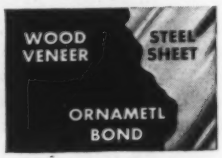
Plymetl *

A lightweight, high quality plywood plaque with light gauge metal sheets permanently bonded to one or both sides. This material has a high *rigid strength-to-weight* ratio, is sound deadening, fire retardant, and high in insulating value. Its flat, smooth metal surfaces take and retain a beautiful finish, free from distorting highlights.

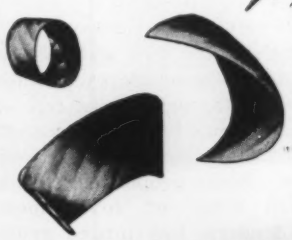


Ornametl *

A thin veneer of choice wood is bonded to thin gauge sheet steel. Ornametl is readily adaptable to production methods and equipment used for fabricating sheet metal. It may be stamped, pressed, or rolled to shape. It can be sawed, drilled, punched, and fastened by welding, nailing, or with metal screws or rivets.



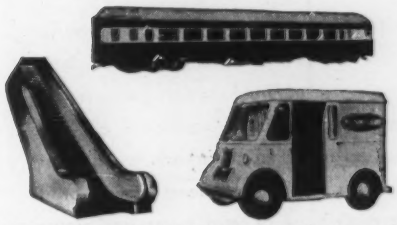
Plymold



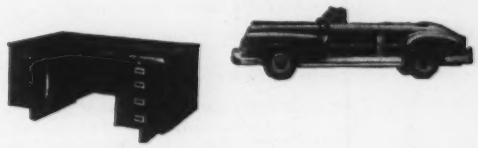
This process permits molding to either simple or compound curvatures, depending upon the material. Fine plywood and other composite materials such as Haskelite Plymetl and Plastiply have been molded by this process in volume quantity.

*T. M. Reg.

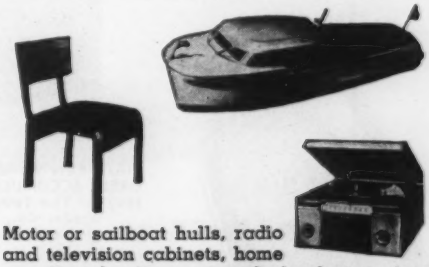
TYPICAL USES



Escalator side panels, interior finish for railway passenger cars. Truck and trailer body panels. Table tops, restaurant counter tops, etc.



Office furniture, station wagon side panels, interior finish for passenger cars, house trailers, home or office interiors, and appliances, clocks, magazine racks, decorative ornaments, etc.



Motor or sailboat hulls, radio and television cabinets, home or office furniture, aircraft fuselage, wing and tail assemblies, etc., in volume quantities.

HASKELITE

Structural materials for men who want better

T.M. Reg.

HASKELITE MANUFACTURING CORP. DEPT. 5 GRAND RAPIDS 2, MICHIGAN

New York Chicago Detroit Philadelphia Los Angeles St. Louis

Canada: Railway & Power Engineering Corp., Ltd.

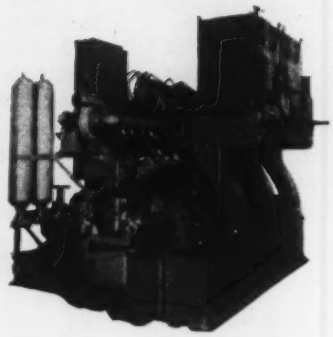
A STORAGE BATTERY FOR YOUR HYDRAULIC SYSTEM

Ever try to start or run your car without a battery? A battery is a mighty important component indeed in an automobile's or similar electric circuit. It serves as a reserve source of electrical energy for peak load requirements such as engine starting, supplements generator output during low engine speeds, supplies power to radio and other accessories and serves as a stand-by in case of generator or engine failure.

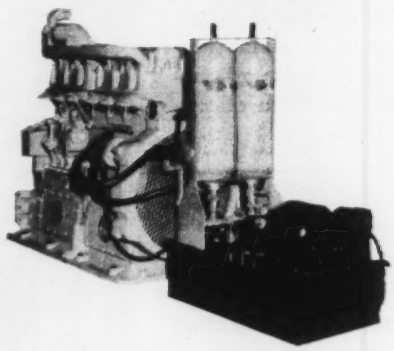
The Greer Accumulator serves much the same function in hydraulic circuits. It stores large volumes of fluid under pressure for instantaneous release for operation of large welding machines, huge presses, cargo ship hatch covers, etc., supplements pump output thus permitting use of small pump and motor, supplies fluid to operate secondary circuits, and operates systems in case of pump failure.

You wouldn't think of operating your car without a battery, why try to operate your hydraulic system without an accumulator?

Get the complete story by writing for our free booklet "Accumulators for Fluid Power". Your copy is ready now.

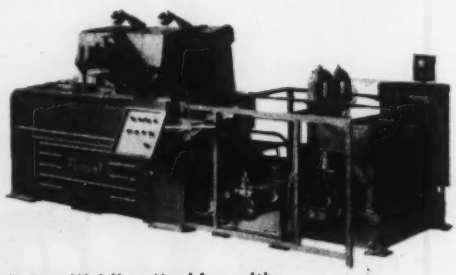


Valve Insert Press with GREER ACCUMULATORS. Photo Courtesy of H. R. KRUEGER & CO., DETROIT, MICH.



Typical Diesel Engine Hydraulic Starter with GREER ACCUMULATORS.

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES



Flash-Butt Welding Machine with GREER ACCUMULATORS. Photo Courtesy of The Federal Machine and Welder Co., Warren, Ohio.

YOUR SYMBOL OF SERVICE

GREER

HYDRAULICS INC.

454 EIGHTEENTH ST., BROOKLYN 15, N. Y.

of severe sparking is not sufficiently long to cause permanent damage to the commutator or brushes. Of course, the frequency of the starts and duration of the normal rush period greatly affect this, but in a normal motor started not over six times an hour, the commutator will be cleaned up by the polishing action of the brushes. Experience has shown that the limit in sparking at the brushes is the flash-over point and that as long as it is avoided, no trouble will result from commutation.

Another point of poor performance in the motor concerns heating. Since the currents are very large, there is some danger of local hot spots developing unless the number of starts is limited so that the local heating has a chance to distribute itself.—*From a paper presented by E. C. Watson, Westinghouse Electric Corp., at the Winter AIEE meeting in New York.*

Designing the Auto Body

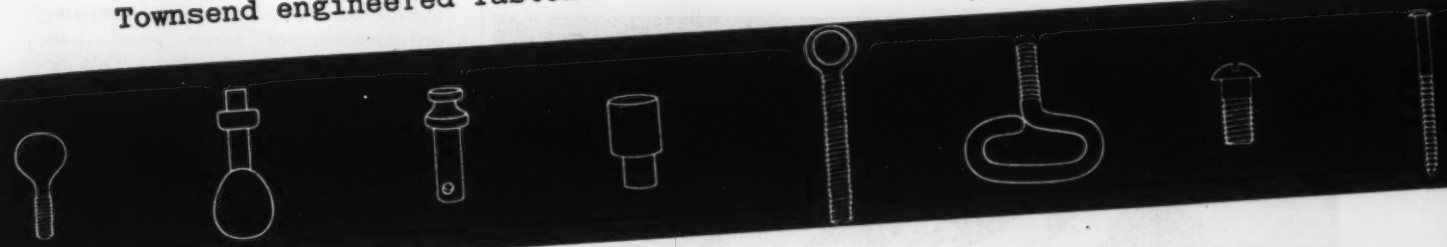
THERE are stringent limitations to our freedom in developing automobile bodies of great beauty and enduring structure. We are restrained and hobbled by the need to develop a product that can be manufactured and sold at a competitive price—a price that the public can afford. This is an especially troublesome problem under present economic conditions. Further, we must develop a product that can be built and delivered in time to meet the market. In this we have two great spurs to keep us on the jump: (1) The rapid obsolescence of car designs (depending, of course, on the intensity of competition) and, (2) the unpredictable spiraling of material and labor costs that we have had to cope with since the war.

Much Hinges on Designer

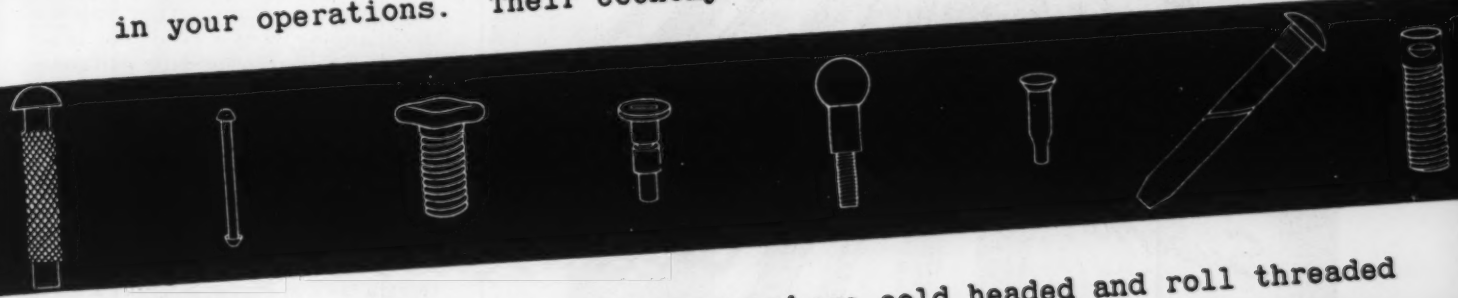
The responsibility of those who create the designs for new automobiles is crucial to the success of any automobile manufacturing enterprise. Body design at its best is, of course, integral to the design of the complete automobile. Some people feel that at the present stage of development, with full fenders, low intake grilles and the like, automobile designing is dangerously approaching a bottleneck of sameness. Such an opinion, of course, is only as valuable as the knowledge of the future plans of the various manufacturers upon which it is based.

The emphasis which General Motors puts on design is reflected in the

Townsend engineered fasteners and parts will save you time and money

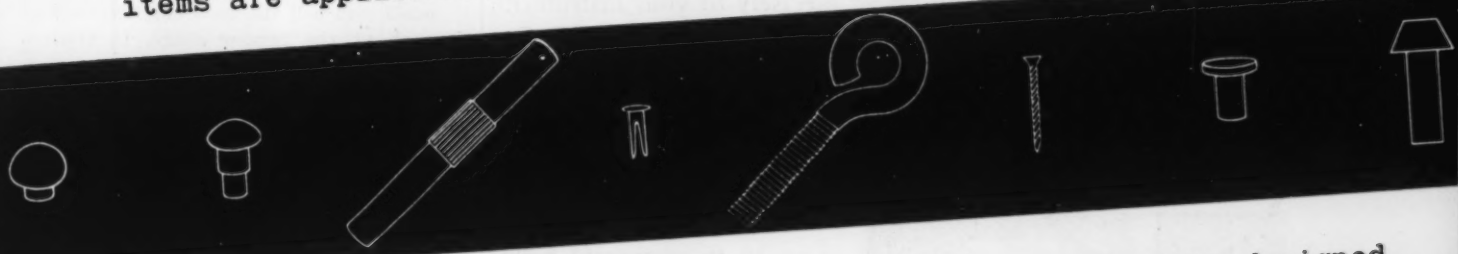


in your operations. Their economy has been proved in many industries

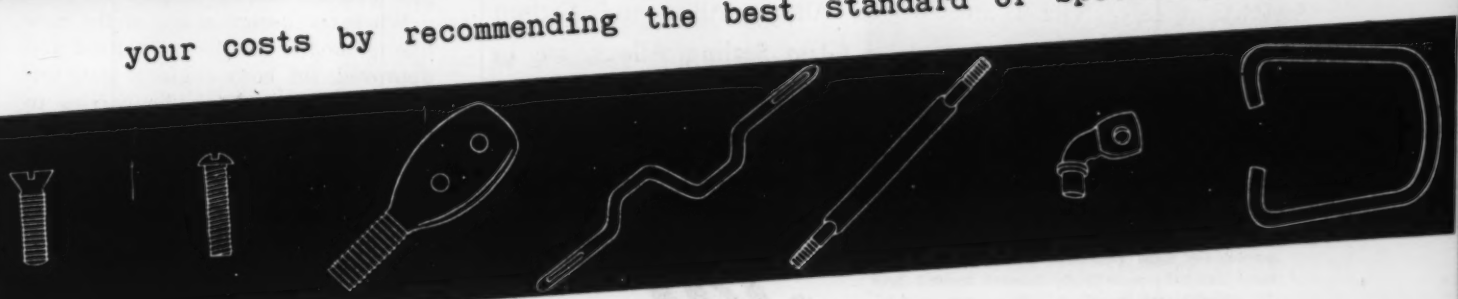


for use with a multitude of products where cold headed and roll threaded

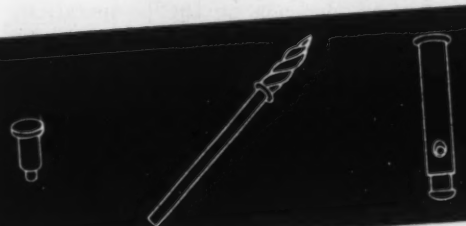
items are applicable. Townsend engineers will be glad to help reduce



your costs by recommending the best standard or specially designed



fasteners and parts for your products. Call or write today to:



(Parts shown one-half size)

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Superior

SMALL SHAPED TUBING

(.010" to ⅝" O.D. Max.)

in any metal that can be cold drawn

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Superior Shaped Tubing, in cut, multiple or random lengths, is available in flat oval, elliptical, square, rectangular or hex shapes. This specialty tubing is produced precisely to your instrument designer's and engineer's specifications.

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Stainless Steels, Nickel and Nickel Alloys, Alloy and Carbon Steels, Beryllium Copper and various Glass Sealing Alloys, are in constant production.

You are invited to consult Superior for fine small metal tubing—to your individual requirements. Write today for Bulletin #31.

Superior

THE BIG NAME IN SMALL TUBING (.010" TO ⅝" O.D. MAX.)

SUPERIOR TUBE COMPANY

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maintenance of a central designing organization of large proportions, called the Styling Section. This organization is headed up by a vice-president of the corporation and it has an extensive staff of executives and creative designers, draftsmen, engineers, sculptors, model-builders, skilled craftsmen in wood, metal, upholstery, paint and the various other materials employed.

These specialists work with ideas far into the future. They explore the changing trends of public taste and acceptance, periodically pull some of their dreams down to earth, and develop complete lines of new models for the five passenger car divisions of the corporation.

Entire Program Co-operative

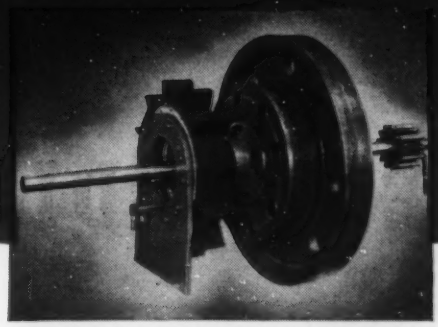
But General Motors designers, even though they are separately organized, do not work in an ivory tower. From the very start they carry on their planning in conjunction with the interested people from the car divisions, the body-building organization, the body hardware division, and the central office staff. Teamwork starts at the very inception of new designs. As the projected designs are carried forward—from sketch to visualization, from small-scale model to full-scale clay and, finally, to full-scale wood and metal—the various members of the several teams that will build and sell the new car are called, each at the proper stage, to confer with the designers. The body and chassis engineers have their opportunity to make recommendations and to develop advance planning for the job that lies ahead. So do the tool designers, the cost accountants, the manufacturing people from all plants, the sales people, the advertising people, and the service people.

When the design stage of the new line of models has been finalized and approved, the body engineer gets under way. Or, rather, he carries to completion the job that he has been pressing forward simultaneously with the designing — transforming the thing of beauty into something that can be manufactured in large volume; something that provides the maximum possible degree of strength and usableness with a minimum sacrifice of beauty. The ultimate success of the design engineer, as he plots the structure that underlies the beauty, depends on the co-operation and follow-through of every single member of the body-building team—and so he is a key factor in promoting and stimulating teamwork. — *From a paper presented by L. C. Goad, General Motors Corp., at the annual SAE meeting in Detroit.*

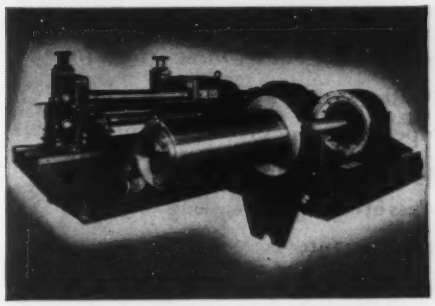
FAWICK-EQUIPPED MACHINES

do More Work at Less Cost

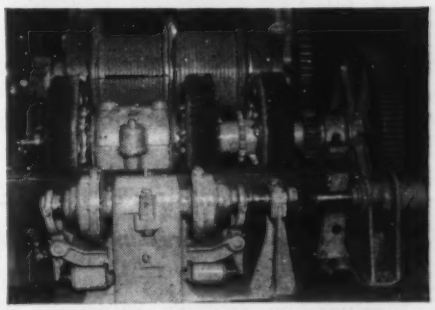
Fawick Air-Ring Clutch or Brake Type E



Fawick Airflex Clutch and Fawick Air-Ring Brake conversion for Bliss Model 6C Press.



Dual Fawick Air-Ring element used as Slip Clutch on Heavy Duty Strip Winder by Steel Equipment Co., Cleveland, Ohio.



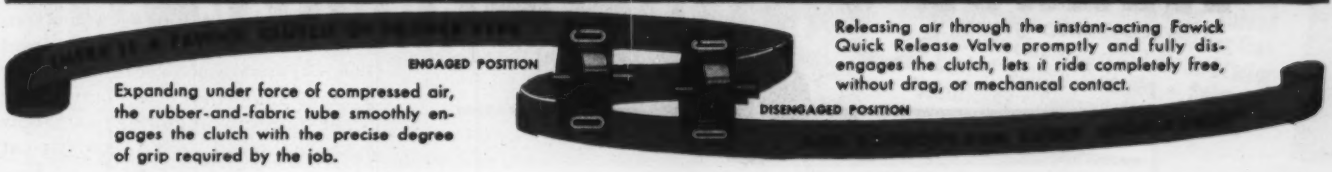
3 Fawick Air-Ring elements used for Swing and Crowd Retract Clutches on Marion Type 362 by Marion Power Shovel Co., Marion, O.

Time-wasting clutch adjustment down time is practically eliminated on Fawick-equipped machines. The moving parts of this Fawick Clutch—the rubber-and-fabric pneumatic tube and the friction shoe assemblies—adjust automatically and compensate for wear.

The smooth engagement action of this Fawick Clutch eliminates sudden shock loads which damage machinery. Controlled torque starting can be obtained with a simple modulating air valve. This type Fawick Clutch is ideally suited to continuous slip applications.

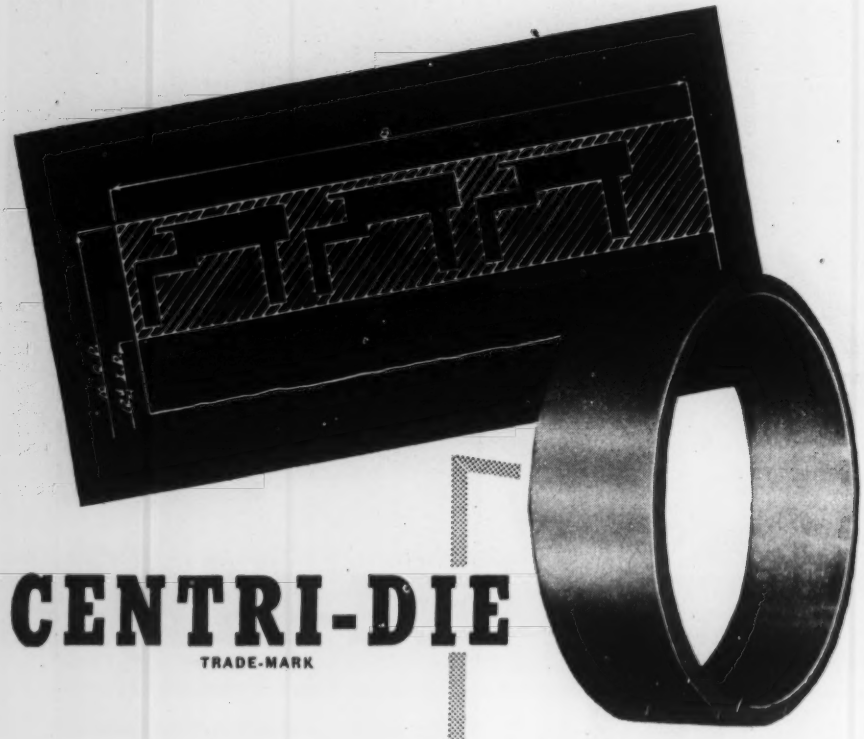
For specific recommendations for your machines, write to our Engineering Department today. Address Dept. MD.

FAWICK Airflex CO., INC.



Expanding under force of compressed air, the rubber-and-fabric tube smoothly engages the clutch with the precise degree of grip required by the job.

Releasing air through the instant-acting Fawick Quick Release Valve promptly and fully disengages the clutch, lets it ride completely free, without drag, or mechanical contact.



CENTRI-DIE
TRADE-MARK

Illustrated above is a cross section of the metal ring shown in the photograph. Notice how three rings of intricate cross section have been grouped in this one cylinder to conserve metal. By Lebanon's CENTRI-DIE process of centrifugal casting a uniform metal structure is assured throughout each ring as finally machined.

A booklet describing this new casting process and the alloys adaptable to CENTRI-DIE production is yours for the asking.

LEBANON STEEL FOUNDRY • LEBANON, PA.
"In the Lebanon Valley"

a NEW casting process which assures greater uniformity of metal structure

Some Advantages of the* CENTRI-DIE *Process of making centrifugal castings

1. Higher quality castings of greater density, resulting in decidedly enhanced physical properties.
2. Readily achieved production of assorted parts and complex structural shapes which cannot be cast satisfactorily by static methods.
3. Uniform strength throughout—a characteristic which does not apply to forgings, as no flow lines exist in castings.
4. The use of alloys which are difficult or impossible to forge, opening the door to applications hitherto considered impractical or too costly.

LEBANON *ALLOY AND STEEL* Castings

CIRCLE L

NEW MACHINES

And the Companies Behind Them

Business Equipment

OFFICE TYPEWRITER. Finished in gray to reduce eye strain. Specially shaped, nonglare keys provide extra clearance between key rows. Cylinder and feed rolls cleaned by lifting out cylinder. Includes nonslip paper feed and newly designed line-space lever. Royal Typewriter Co., New York.

DUPLICATOR. All operations on gelatine system duplicator handled with operator in seated position. Prepares copies of any business form on paper or card stock to 14 by 17 in. Low-cost gelatin system delivers copies face up and flat. Ditto Inc., Chicago.

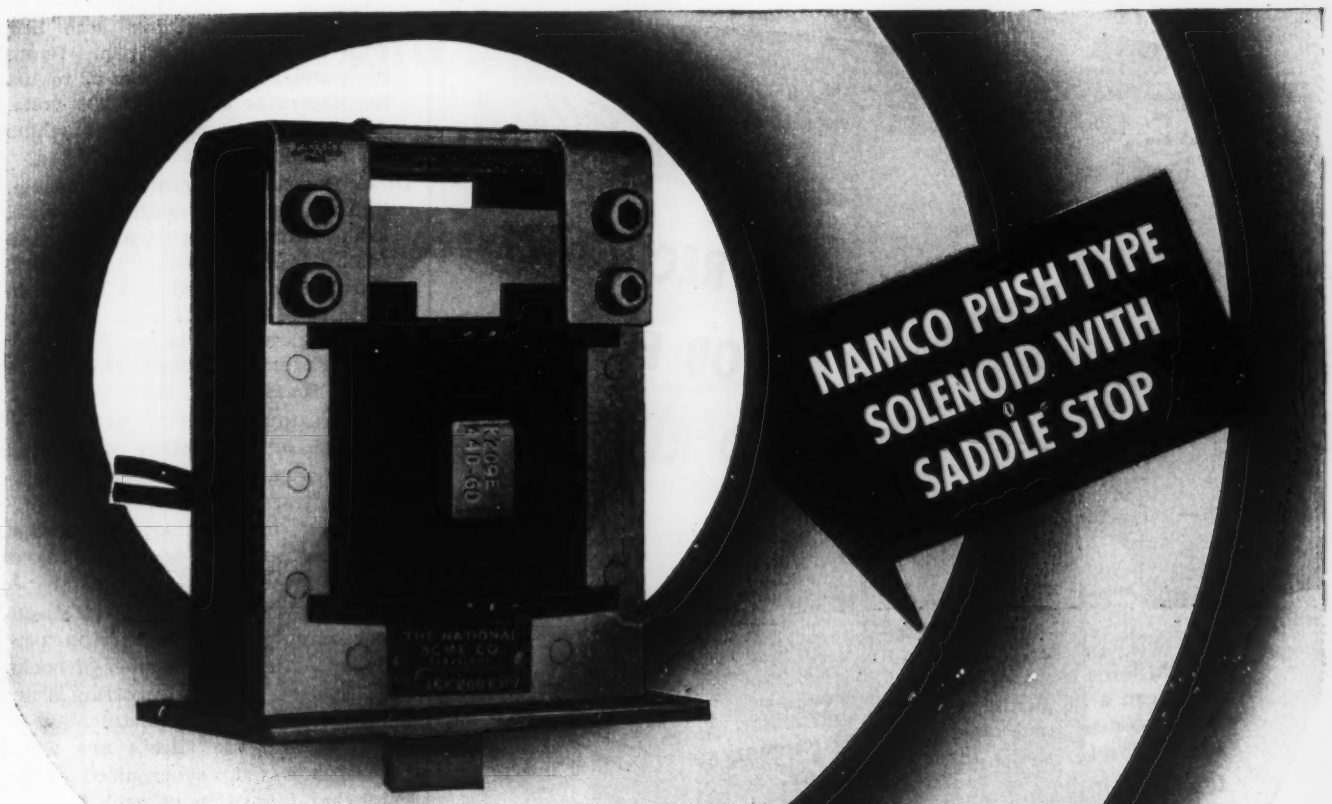
Commercial

PRECIPITRON. All-aluminum model handles 10 per cent more air than previous models of same size. Three-inch additional plate length provides 17 per cent more dirt-trapping area using 99 instead of 111 plates. Capacity of 36-in. wide model, 1000 cfm; capacity of 24-in. wide model, 667 cfm. Lighter weight makes unit easier and cheaper to install. Westinghouse Electric Corp., Pittsburgh.

LIGHTWEIGHT GAS ENGINE. Weighs 23 lb, develops ¾-hp. Engine is 4 cycle; has 1⅝-in. bore, 1½-in. stroke, and 3.11 cu in. piston displacement. Includes ball bearings on crankshaft, automotive type carburetor, fly-ball governor, and high-tension magneto. Suitable for powering portable equipment such as lawn mowers, pumps, compressors, sprayers, etc. Lauson Co., New Holstein, Wis.

DIAL SCALES. Tape drive principle eliminates inaccuracies of conventional rack and pinion movements. Self-aligning, noncorrosive tapes. Mechanism self-compensating for temperature changes. Valve type dashpot plunger allows maximum adjustment. Howe Scale Co., Rutland, Vt.

FLOOR SANDER. Lever type 8-in. sander powered by 2-hp, 1750-rpm motor. Drum speeds adjustable between 1600 and 2800 rpm by pressing button in hub of drum pulley and dialing speed desired. Dial changes diameter of drum pulley to vary speed. Vari-speed power transmission permits motor to start under no load, automatic V-belt take-up engaging as motor picks up speed. Fan running at



FOR *successful* SOLENOID OPERATION

—we engineer them to your needs

A push—or a pull—built into your machine—can save time and money—if it's specifically designed to do the job *right.*

That's where Namco "Stellite"-Welded Solenoids shine. For some applications they'll even replace fractional horsepower motors; they're built in capacities up to 25 pounds—and custom-engineered to your needs, overcoming such hazards as oil, vibration and atmospheric conditions, if these are your problems.

If you want something more in the way of solenoid service than mere shelf-stock, hit-or-miss operation (not the kind that's good enough for toys and cheap household appliances)—if you want precision and uninterrupted trouble-free action on heavy-duty production-line jobs—then you'll want the best—Namco Solenoids. For the "how" of *successful* solenoid application, consult with us.

Namco "Stellite"-Welded Solenoids are built in a variety of sizes and mountings, both push and pull types, to meet every commercial application. The complete standard range is illustrated and tabulated in Engineering Bulletin EM-46. Ask for your copy.

The NATIONAL ACME CO.

180 EAST 131st STREET • CLEVELAND 8, OHIO

Acme-Gridley Bar and Chucking Automatics: 1-4-6 and 8 Spindle • Hydraulic Thread Rolling Machines • Automatic Threading Dies and Taps • The Chronolog-Limit, Motor Starter and Control Station Switches • Solenoids Centrifuges • Contract Manufacturing

HOW TO RECOGNIZE A JOB FOR HARD RUBBER

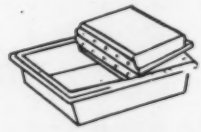
How can a man think straight about materials when so many new ones are always popping up. Now take hard rubber, for instance.

It's been all around us for nearly a century. Let's clamp down on our hard rubber pipe bits, ease ourselves down on our rubber casters, and take a good look. From an impartial viewpoint. (*We* can, because Ace molds *both* hard rubber and other important plastics).

First, we see dozens of grades of hard rubber, and they're all different. Generally speaking, they're black beauties, easily polished, with a real nice feel. *Good* for handles, grips, pipe bits, knobs, combs, etc.

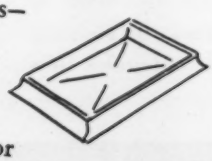
We see it's tough, stable stuff that's well nigh impervious to water and 'most all known chemicals. (Except mineral oils and organic solvents— but Ace *synthetics* take care of them.) Its resistance to water is topped only by Ace polyethylene.

Tensile strength of hard rubber is up with the best plastics—up to 9,700 psi. Coefficient of expansion is very low—good for refrigerator parts. For the hot spots, we can give you compounds that won't distort up to 250° F., but don't count on more than 150° from any general purpose mix.



You probably know all about the top-notch electrical properties of hard rubber. But did you know its wear resistance is so good it's often used in bearings? So tough it's used in bowling balls.

Add it all up—Ace hard rubber is good for a lot of things—water meter parts, magneto parts, foot tubs, vinegar dumpers, fountain pen parts, sparges (if you know what *they* are) and chemical piping. It's probably natural for a lot of things you make, too.



Want to know more? Just tell me your problems or ask for a copy of our new Hard Rubber and Plastics Handbook.

ACE

HARD RUBBER and OTHER IMPORTANT PLASTICS

AMERICAN HARD RUBBER COMPANY

Since 1851

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4500 rpm carries dust into bag with replaceable dust pan. Drum pressures adjustable from 52 to 103 lb. Operates on 115 or 230 volts. American Floor Surfacing Machine Co., Toledo, Ohio.

DUAL RECORD TURNTABLE. Portable, lightweight unit with individual table controls for switching and fading from one record to another. Turntables removed and stored in 15½ by 7¾ by 11½-in. case for carrying; weight, 16 lb. Will play through any amplifier. Movie-Mite Corp., Kansas City, Mo.

TRIP BALANCE. Capacity, 210 grams. For laboratory or other commercial work. Employs stainless steel weighing platforms and beams, and self-aligning agate bearings against hollow-ground tool-steel knife edges. Ohaus Scale Corp., Newark, N. J.

AUTOMATIC COLLATOR. Sorts 85 sheets per minute. Automatic stop permits collating any number of books to 50. Uses vertical revolving drum composed of 50 compartments into which duplicate sheets are automatically fed, syncronized drum moving 1 position as each sheet is sorted. Reproduction Products Co., Chicago.

Domestic

WASHING MACHINES. Capacity, 10 lb. Require 19 gal water to fill to load line. Tub diameter, 23 in. Include spiral agitator, heat retaining jacket around tub on some models, and motor driven drain pump. Appliance Manufacturing Co., Alliance, Ohio.

ELECTRIC WATER HEATERS. Capacities, 40, 50, 67, and 82 gal. Designed for kitchen installation. All models require same floor space, vary only in height. Magnesium rod antirust protection; belt heater heats wide area of tank surface. Heat-control dial permits adjustment of water temperature between 120 and 170 F. McGraw Electric Co., Chicago.

Earthmoving

EXCAVATORS AND CRANES. Capacity, ⅝ cu yd. For construction work or factory materials handling. Fully rubber tired, with lever shift from 4 to 2-wheel drive, 27½-ft turning radius, air clutches and brakes, hydraulic power steering, and gas or diesel power. For one-man operation, units are convertible to all attachments. Byers Machine Co., Ravenna, Ohio.

Heating and Ventilating

FAN. Capacity, 500 cfm; fan blade diameter, 10 in. Air stream can be directed at any angle through 360 degrees. Plated fan guard and

Gear errors and Gear noise

should be discovered long before the gears reach final assembly . . .

There is a profit in scrap for the scrap dealer, but most certainly not for the gear manufacturer who suddenly discovers that an entire lot of gears have to be scrapped because they fail to meet tolerance requirements or because they are too noisy.

If economy is important in your plant, the time to find out about machining errors is right at the machine which causes the trouble—not after all the subsequent operations including heat treatment have been completed and the gears assembled in some power unit.

The best insurance against high cost of scrap gears is the use of gear checking machines right down there in the plant where the gears are being produced and where they can be checked periodically by the machine operators.

The Red Ring Gear Checker quickly reveals any dimensional errors and the Red Ring Gear Sound Tester immediately puts an accusing finger on noisy gears. Both machines have laboratory accuracy, they can be used anywhere in the plant or inspection department and they prevent a great deal of waste.

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aluminum blade included. Shaded pole induction motor requires 105 to 120-volt, 50 to 60-cycle current. Rubber molding around 8-in. base makes unit mountable on any surface. G-M Laboratories Inc., Chicago.

Industrial

MAGNETIC SEPARATOR. Nonelectric magnet unit provides protection for crushers, grinders, pulverizers, etc., by removing iron from food, grains, liquids, coal, etc. Installed over conveyor belts, spouts or chutes. Tramp iron attracted to underside of cross belt, carried aside and automatically discharged. Uses C-shaped Alnico magnets. Available in sizes to suit requirements. Dings Magnetic Separator Co., Milwaukee.

ELECTRIC WOODWORKING MACHINES. Portable. Single 1-hp universal motor can be attached to any one of four tools: high-speed router with built-in micrometer adjustment; precision shaper providing 18,000 rpm cutter speed; power plane with chatter proof, graduated depth adjustment; and mortiser with automatic feed. Automatic adjusting end-thrust bearing in motor. Porter-Cable Machine Co., Syracuse, N. Y.

CRANE CAB. Permits operator lateral vision of 240 degrees and vertical view almost straight down. Uses magnetic switching controls; crane movement governed by slight push or pull on short, ball-tipped levers connected to low-voltage, multipoint, time-delay speed controls. Weatherproof cab may be provided with air conditioning and telephone. Whiting Corp., Harvey, Ill.

IMPACT AIR HAMMER. Capacity, 15,000 lb at point of impact. Working surface of table, 7 by 9 in.; over-all height, 44⅛ in. Has 4½-in. throat depth, 18-in. max opening and 8-in. max stroke. Mead Specialties Co., Chicago.

BAND SAW. Power band saw uses spiral blade, 360-degree cutting edge permitting cutting in any direction. Saw speed range of 70 to 5000 fpm available with planetary transmission giving operator choice of any speed within range. Saw will cut to center of stock to 24-in. wide. Blade will cut any material from steel to foam rubber. Combination guide on saw permits use of conventional flat blades in addition to spiral blades. Tyler Manufacturing Co., Los Angeles.

MECHANICAL PARTS DRIER. For spotless drying of metal parts on continuous racks or monorail systems. High velocity, adjustable jet nozzles use combination of cold and

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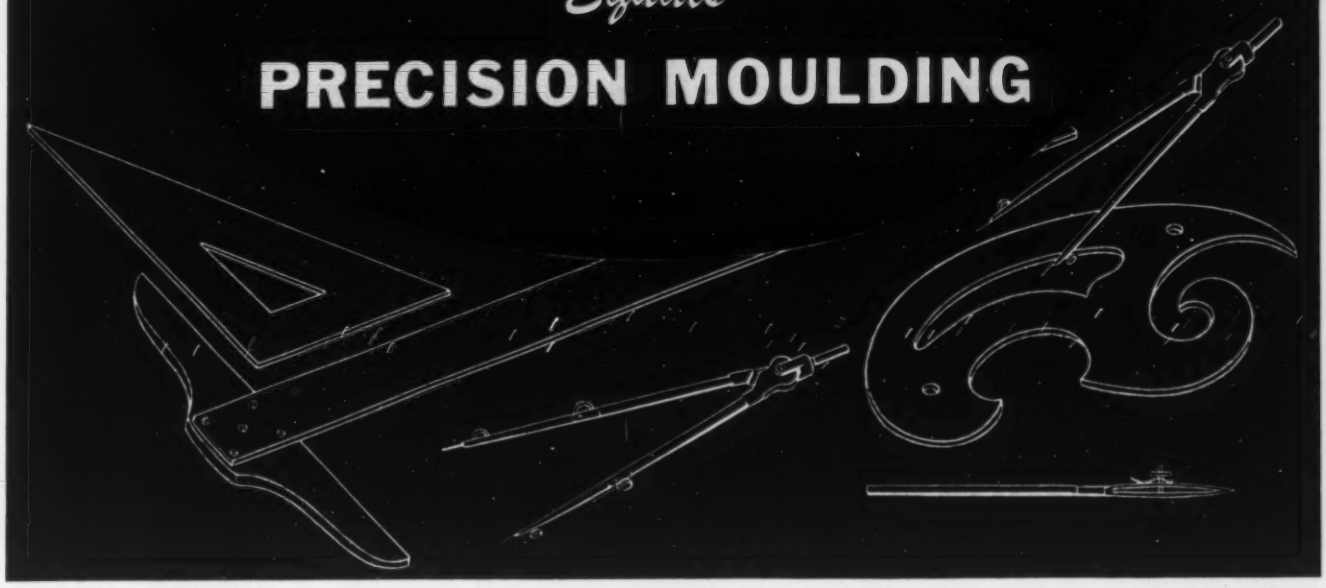

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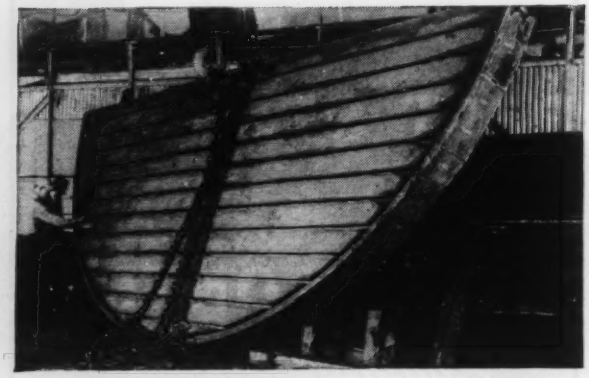

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PROFILE PROJECTOR. For checking and measuring parts at different magnifications and illuminations. Magnifications; 10, 20, 50, and 100X. Lenses turret mounted. Reading accuracy on screen; approx. 0.006-in., corresponding to an error on the part of 0.00006 at 100X. Complete with lenses, filters and transformers. Hauser Machine Tool Corp., Manhasset, N. Y.

Manufacturing

AIR PRESS. For staking, press fit assembling, light stamping, marking and similar successive operations. Model with 4-in. cylinder bore has power factor 12.56 times line air pressure; 5-in. cylinder bore model has power factor 19.63 times line pressure. Both models have 2½-in. stroke, ¾-in. ram, 6-in. depth of throat and 7-in. table-to-ram height. Paragon Metal Products, Chicago.

ELECTRIC SANDER. Portable. Can be used on curved surfaces through use of flexible sponge rubber pad attachment. Orbital sanding motion eliminates cross-grain scars since sanding pad moves in 3/16-in. orbit at 5000 cycles per minute. Sterling Tool Products Co., Chicago.

ACOUSTICAL TILE DRILLING MACHINE. Drills 441 holes in 12 by 12-in. tile by use of drilling head allowing close spindle centers. Length of drill stroke and feed rate adjustable. Automatic cycling included. Available in capacities to handle various tile sizes. Zagar Tool Inc., Cleveland.

HYDRAULIC VISE. Swivel type, foot-operated, machinist's vise with 3½-in. jaw width and 6-in. opening. Leaves operators hands free for handling work. Vise closed by foot-operated pump; opened by coil spring. Jaw stopped at any position by releasing pedal. Max pressure, 6000 psi. Columbian Vise and Manufacturing Co., Cleveland.

AIR-OPERATED CHUCK. Combines features of air and power wrench operated chucks. Center hole allows feeding stock through center of unit. Chuck housing attached directly to lathe head. Air motor drives pinion which engages scroll, causing jaws to open or close. Whiton Machine Co., New London, Conn.

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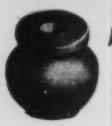

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in 22 to 26 gage with 3¼ in. of metal; drive cleat in 20 to 26 gage using 4½ in. of material; and double seam in 20 to 26 gage with 1 in. of material. Roll stands progressively geared to prevent crimping between rolls. Unit 24 by 48 by 38 in. powered by 110-volt, ¾-hp motor through V-belt drive. Roy G. Flagler Manufacturing Co., Detroit.

TILTING ARBOR CIRCULAR SAW. Floor model, 8-in. blade unit has motor and all working parts enclosed in cabinet. Table size; 25 in. deep, 33 in. wide, 12 in. max in front of blade. Max capacity cut, 2 5/16 in.; max cut at 45 degrees, 1⅝ in.; max width dado cut, 13/16 in. Requires ¾ or 1-hp, 1725-rpm motor to give blade speed of 3800 rpm. Blade guard rides with work. Delta Mfg. Div. of Rockwell Mfg. Co., Milwaukee.

INJECTION MOLDING MACHINE. Single-shot, 48-oz, automatic machine for molding of thermoplastics. Automatic stuffing arrangement increases rated capacity by 50 per cent. Both manual and automatic cycle controls available through selector switch. Injector plunger and clamp ram have speed and pressure adjustments. Injection pressure, 21,000 psi; clamping capacity, 1000 tons; stroke of clamping ram, 32 in. Watson-Stillman Co., Roselle, N. J.

AIR PRESS. Piston held and cylinder driven. Capacity; 400, 1200 and 2000 lb. Air cushion cylinder built in large cylinder changes action from hard blow to squeeze action by regulating control valve. Dimensions; 10½ by 10 by 17¼ in. (400 lb press) to 15½ by 12 by 24 in. (2000 lb press). Clayton Manufacturing Co., Buffalo.

Materials Handling

ROLL HANDLING TRUCK. Capacity, 2000 lb. Picks up, moves and deposits rolls using rubber-lined grip pads on hydraulically-opened clamper arms. Clampers closed by tension springs actuated by operator. Holding of load in transit is independent of hydraulic system. Clamper adjustable for various size rolls. Lewis-Shepard Products, Watertown, Mass.

HIGH-LIFT FORK TRUCK. Capacities, 3000 to 5000 lb in 3 models. Total lift, 130 in.; free lift, 65 in.; lowered mast height, 83 in. All models feature good visibility and simplicity in construction. Towmotor Corp., Cleveland.

INDUSTRIAL TOWING TRACTOR. Redesigned steering system reduces front wheel tread from 27 to 22 5/16 in., permitting wheels to be turned

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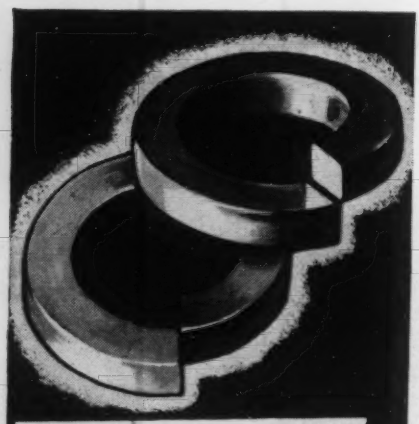

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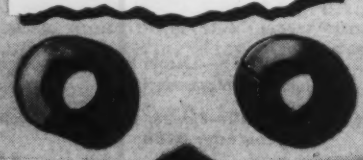

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to extreme position within body of machine. Steel plate beneath axle protects steering mechanism; axle made stronger and uses fewer parts. Clark Equipment Co., Battle Creek, Mich.

HAND PALLET TRUCK. Battery operated. Automatic power cut-off stops motor and applies brake if control handle is released. Includes control buttons on handle for right or left-hand operation, 3-point suspension, and differential action trailer wheels. Towmotor Corp., Cleveland.

STRADDLE TRUCK. For pipe laying. Capacity, 30,000 lb; width, 11½ ft; height, 13 ft; and length, 16¼ ft. Used to straddle ditches in handling 40-ft pipe sections weighing 11 tons each and measuring 56 in. in diameter. Hyster Co., Portland, Oreg.

Metalworking

ROTARY TABLE MILLER. Hydraulically-controlled, 16-in. diameter rotating table replaces standard table. Rotary action obtained through gear and hydraulic-cylinder actuated rack. Spindle speeds range from 64 to 860 rpm in 12 increments. Head mounted on 2 cylindrical steel posts carrying spindle midway between them for added rigidity. Kent-Owens Machine Co., Toledo, Ohio.

DRILLING AND TAPPING MACHINE. For automobile dual-carburetor intake manifolds. Drills, reams and taps 155 pieces per hour. Includes 5-station power index with independent station for loading and unloading. Progressive cutting of 4 pieces at a time. Incorporates overload protection on index drive, hydraulic feed for drilling and reaming, and lead-screw feed for tapping. Cross Co., Detroit.

SQUARING SHEARS. Capacity, ⅜ to 1¼-in. mild steel from 6 to 10 feet long. Worm-gear drive provides quiet and vibration-free operation. Includes electric solenoid-operated clutch actuated by foot switch, automatic hydraulic hold-downs, and motorized back-gage controlled by electric motor and pushbutton switch. Eccentrics are integrally forged on eccentric shaft. Furnished with special finger guard. Columbia Machinery and Engineering Corp., Hamilton, Ohio.

DUPLEX SURFACE BROACH. Machines large diesel bearing supports. Automatic cycle of left-hand table and right-hand broach arbor, both of which index 6 times in broaching one complete cycle. Approximately ½-in. metal removed on 110 sq in.

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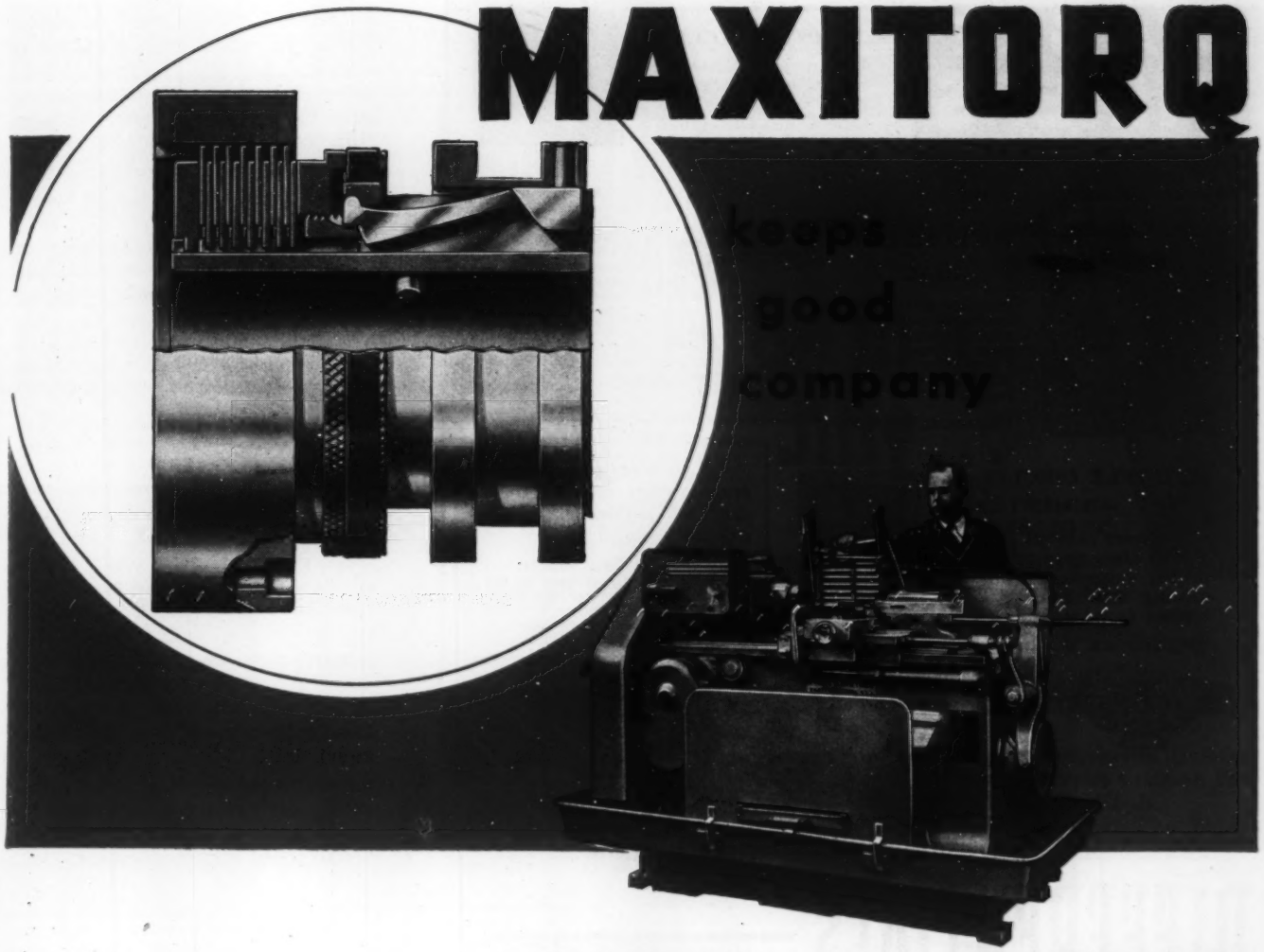

Another leading machine tool builder . . . Pratt & Whitney Division, Niles-Bement-Pond Co., has selected the Maxitorq Floating Disc Clutch as original equipment in their 1¼x16 Model C Automatic Lathe. It is used in the feed drive for obtaining rapid traverse return of the carriage at the completion of each cut. For this fast feed, the single clutch operates directly from the motor . . . with the cutting feed drive declutched. Clutch operates once each cycle.

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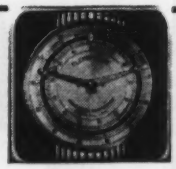

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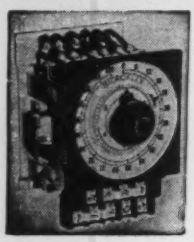
Use for limiting a process to an exact number of operations. The counter contact opens after 1 to 400 electrical impulses as selected on dial. Automatic spring reset.

(MICROFLEX COUNTER)



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Provides exceptional timing accuracy where a circuit is to close or open with a time delay. Timing adjustable over wide range.

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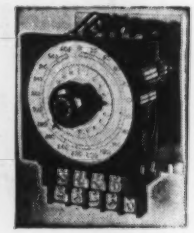

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Use where several circuits are to close in a predetermined sequence. Time of closing and opening each circuit is adjustable.

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of surface. Capacity, 40 tons; stroke, 72 in. Interlocked electrical controls provide continuous machine cycle during 6 passes necessary to complete 1 part. Includes chip conveyor. American Broach and Machine Co., Ann Arbor, Mich.

WET TOOL GRINDER. Grinding wheel driven by rubber friction roll; peripheral speed remains constant at 280 fpm as wheel wears. Grinding angles controlled from 0 to 30 degrees. No water thrown on operator from 8-in. diameter, 1½-in. face sandstone wheel. Boice-Crane Co., Toledo, Ohio.

HORIZONTAL MULTIPLE PUNCH. For multiple punching flanges of long, wide sheets. Capacities, 50 to 300 tons. Punch tools mounted on varying centers on ram face. Air clamp holds material during punching and gaging operations. Sheets stripped by air cylinders traveling with ram. Dimensions of 200-ton punch: stroke, 6 in.; strokes per minute, 28; die space with ram back, 18¼ in.; ram size, 10¾ by 72 in.; and table size, 9 by 72 in. Beatty Machine & Mfg. Co., Hammond, Ind.

GRINDER. Double vertical spindle machine for precision grinding of small parts. Output with manual loading by skilled operator, 2400 pieces per hour; with hopper feed attachment, 5000 pieces per hour or more depending on areas of pieces to be ground. Replaceable feed wheel provides for quick setup. Gravity loading and unloading obtained by horizontal position of feed wheel. Two 3-hp motors power grinding heads at 1750 rpm. Charles H. Besly and Co., Chicago.

ELECTRIC GRINDER. Portable. Weight of motor of verticle type machine helps operator grind with less effort. Operating speed of 3-phase, 60-cycle, 230-volt motor: 3400 rpm. Sizes: 1, 1½ and 2-hp. Gaston Power Tools Inc., Harvey, Ill.

BROACHING MACHINE. Hydraulically operated. Capacity, 3 to 32 tons; stroke, 30 to 66 in. Double tip-down fixture permits loading work on one table while other table is in broaching position. Includes dual controls for operator safety, dial speed control, and force feed lubrication system. Lapointe Machine Tool Co., Hudson, Mass.

THREAD ROLLER. For rolling continuous or noncontinuous threads, knurls or serrations. Capacity, 0.138 to 4 in., with max of 8 pitch. Regular length of thread when not through-rolling is 2¼ in. standard, 3¼ in. max. Two 6½-in. average diameter cylindrical dies provide

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Off in a Jiffy...

Your customer makes speed changes quickly with the two-piece QD Sheave.

The rim comes off easily—the pull-up bolts are used as jack screws to break the tapered fit between rim and hub.

Installing is just as easy. The light-weight split hub is locked in place first . . . then the tapered-bore rim is pulled up over the tapered-cone hub.

And the QD *stays tight* on the shaft. The cone-friction grip on the hub produces a positive press fit on the shaft. The QD clamps the shaft tighter than any other sheave on the market.

For Balanced Drive Performance

Specify Worthington Multi-V-Drives, with QD Sheaves and Worthington-Goodyear EC V-Belts. Each strand in the belt carries its equal share of the belt load, as each belt carries its full share of the drive load. (Goodyear EC Cord or Steel Cable V-Belts are used exclusively in Worthington Multi-V-Drives.)

Complete Range of Stock Sizes—Prompt Shipment

853 listed stock sizes in "A", "B", "C" and "D" sections, fhp to 200 hp . . . 332 listed stock sizes of EC Cord V-belts. Send coupon for latest Worthington QD Sheave bulletin.

Worthington QD Sheave—Original Tapered Cone-Grip Sheave. Easy to Get On—Easy to Get Off—Yet Always Tight on the Shaft. The Quality-Built Sheave That Makes Alignment Easy—for Longer Belt Life.

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Worthington Pump and Machinery Corp.
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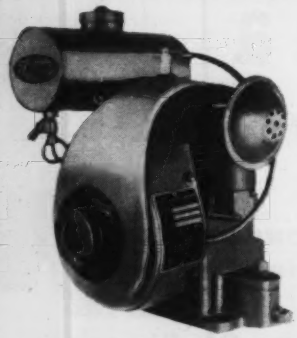

- Here's that famous Lauson dependability — now available in an engine weighing only **23 lbs!**
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Combined Flexible and Safety Coupling. Free running after overload release. Self-reengaging. Several different types to meet all requirements.

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200 to 540 fpm surface rolling speed. Adjustable cycle control, positive stop and micrometer size control. Watson-Flagg Machine Co. Inc., Paterson, N. J.

THREAD ROLLER. Capacity, ⅝ to 4 in. Horizontal type machine supports blanks between 3 synchronously rotating cylindrical dies. Includes positive adjustments for diameter, length and taper. Cam actuated mechanical feed provides controlled rate of penetration, predetermined length of dwell and positive duplication of size. Jogging pushbutton controls for die rotation and feed facilitate set-up. Die speeds, 115 to 640 rpm in 5 steps; work cycles, 2 to 26 per minute in 7 steps. Reed Rolled Thread Die Co., Worcester, Mass.

Service Equipment

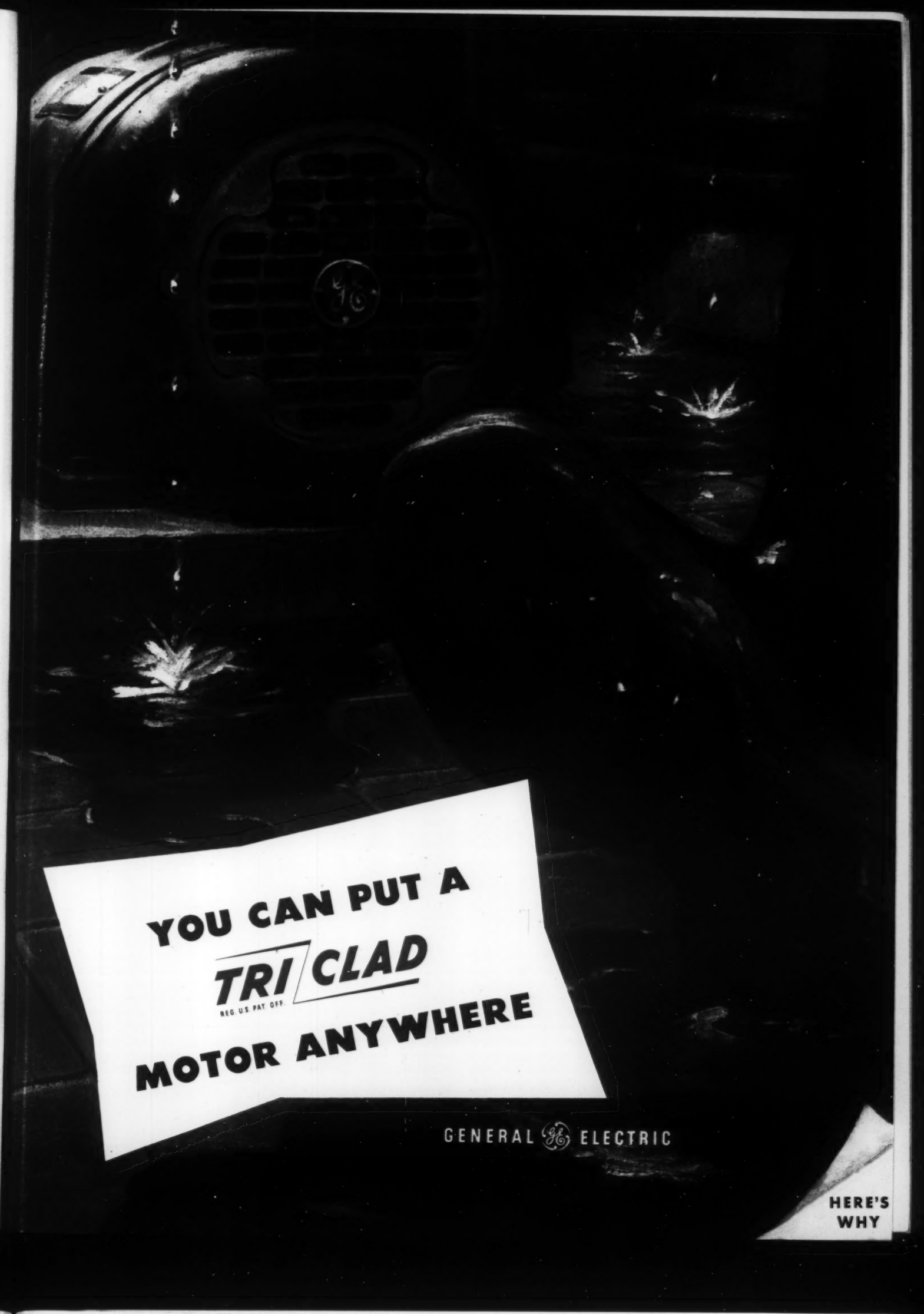
COMPRESSOR UNITS. For spray painting or other applications requiring to 200 psi working pressures. Capacities, 7.13 to 40 cfm in 6 models powered by 1½ to 10-hp motors. Two-stage compressors have loadless starting mechanism that unloads compressor until motor is at full-load speed. Motors are equipped with overload protection starter switches. Binks Manufacturing Co., Chicago.

Testing

FATIGUE TESTER. For vibration fatigue testing of parts weighing to 10 lb at frequencies from 10 to 55 cycles per second. Work clamped to table subjected to simple harmonic motion in vertical direction. Frequencies can also be manually controlled and held at any frequency between 10 and 60. All American Tool & Mfg. Co., Chicago.

ROCKWELL HARDNESS TESTER. Spindle housing and beam assembly replaceable. Frictionless spindle assures correct minor load; more positive tripping reduces possibility of incorrect major load. Cast aluminum body reduces weight about 75 lb under former tester. Clark Instrument Inc., Dearborn, Mich.

DUCTILITY TESTING MACHINE. For testing drawing qualities of sheet metal. Capacity, 15,000 lb to cup-test material to ⅛-in. thick or 30,000 lb for material to ¼-in. thick. Speed of piston travel adjustable. Outer piston grips test piece agaist head and inner piston makes cup in specimen. Bench model machine, 35 by 26 in., is motorized and hydraulically operated. Gage shows pressure at which yield occurs, depth indicator shows depth of draw. Steel City Testing Machines Inc., Detroit.


YOU CAN PUT A
TRI CLAD
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GENERAL ELECTRIC
HERE'S
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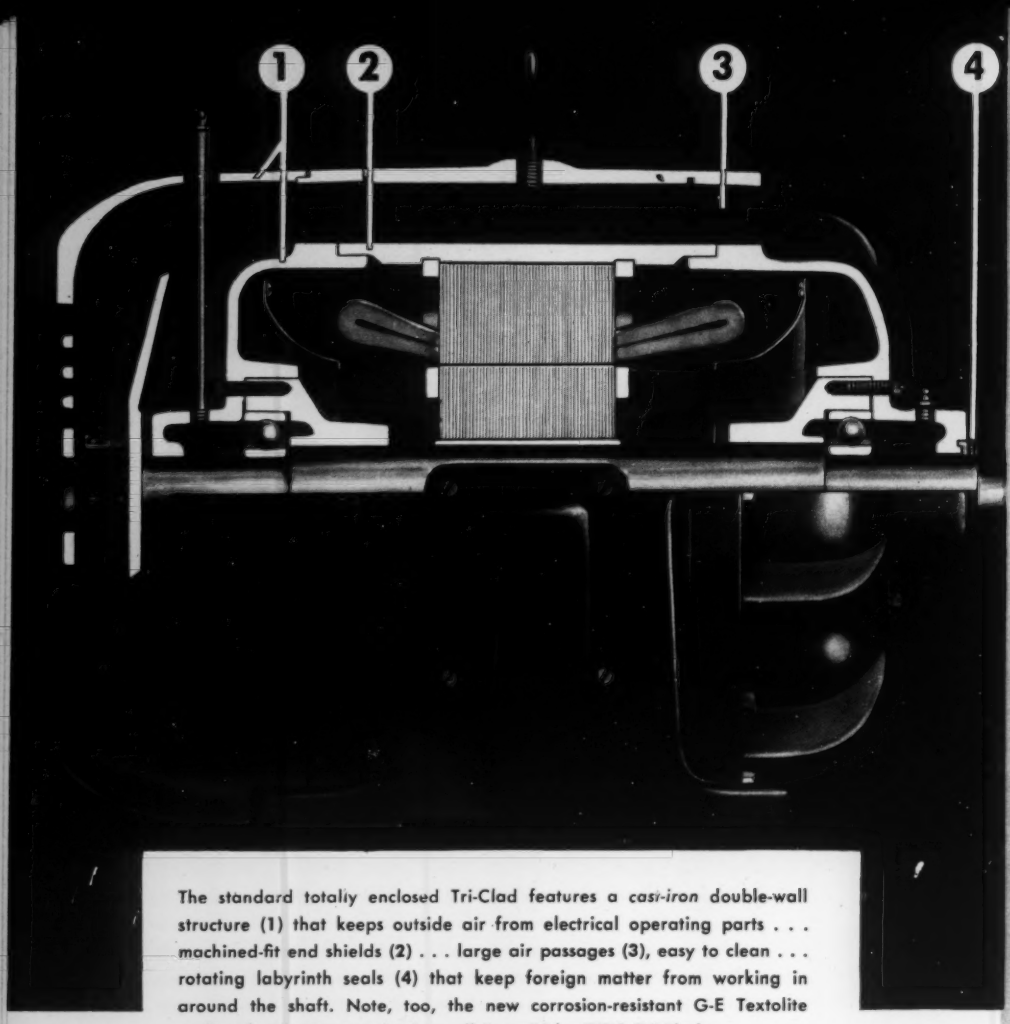


The standard totally enclosed Tri-Clad features a *cast-iron* double-wall structure (1) that keeps outside air from electrical operating parts . . . machined-fit end shields (2) . . . large air passages (3), easy to clean . . . rotating labyrinth seals (4) that keep foreign matter from working in around the shaft. Note, too, the new corrosion-resistant G-E Textolite cooling fan is now standard on all 1- to 15 hp TEFC Tri-Clads.

You can put a *TRI CLAD* motor anywhere

YES SIR! The standard *Tri-Clad* open motor is a *cast-iron, dripproof* motor you can put anywhere that *any* open motor can be used—and in a lot of places where other open motors couldn't take it.

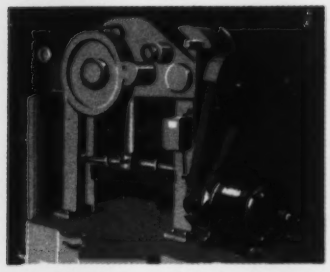
What's more, for the really dirty jobs—where air is laden with dust, or corrosive fumes—where metal chips and cutting fluids abound—the Tri-Clad totally enclosed motor gives you more protection, *inside and out,* than any other make of motor you can buy.

1,720,000 Tri-Clad motors, operating in every conceivable kind of plant, prove the far-reaching advantages of cast-iron construction . . . superior resistance to corrosion . . . rigidity that makes for permanent shaft alignment . . . inherent damping action that minimizes noise and damaging vibration. These motors prove, too, that Tri-Clad double-end ventilation simply has no equal for prolonging an open motor's useful life. Providing high-volume, relatively low-velocity cooling, this ventilating system keeps Tri-Clad motors *uniformly* "air-conditioned".

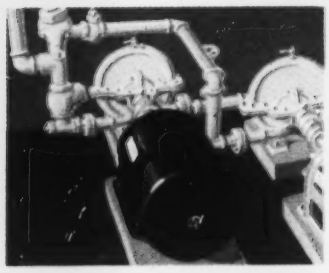
WANT MOTORS THAT CAN REALLY TAKE ABUSE? Tri-Clad motors in nearly all types and ratings are available for **IMMEDIATE SHIPMENT.** Contact your nearest G-E Office or write *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

There's a Tri-Clad motor for every industrial need!



G-E open (dripproof) induction motors for constant-load, constant-speed applications. From 1 to 2000 hp.



G-E totally enclosed motors for outdoor operation, in abrasive dusts, or corrosive fumes. From 1 to 1000 hp.

G-E gear-motors for low-speed operation. A normal-speed motor with built-in reduction gear. From ⅛ to 75 hp.

G-E synchronous motors for maintaining exact speeds or for correcting power factor. From 20 to 1000 hp.

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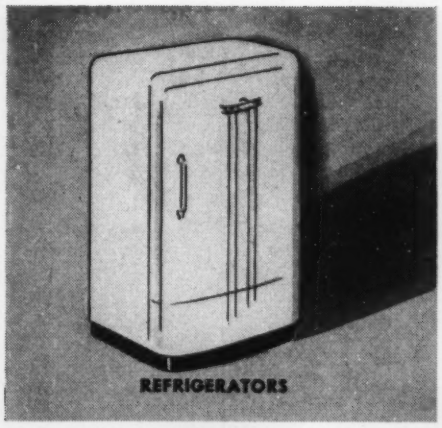
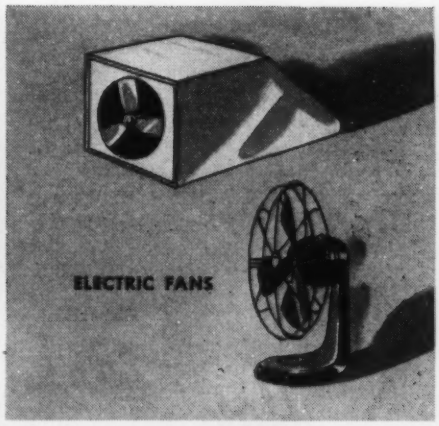
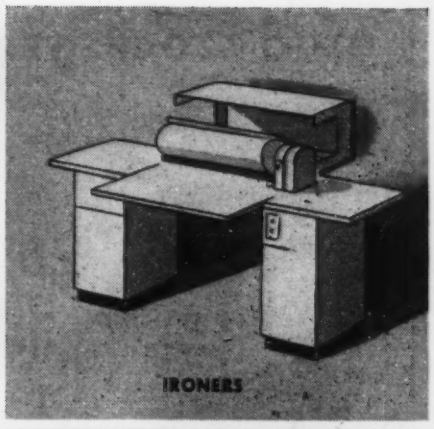

REFRIGERATORS


ELECTRIC FANS


IRONERS

WASHING MACHINES

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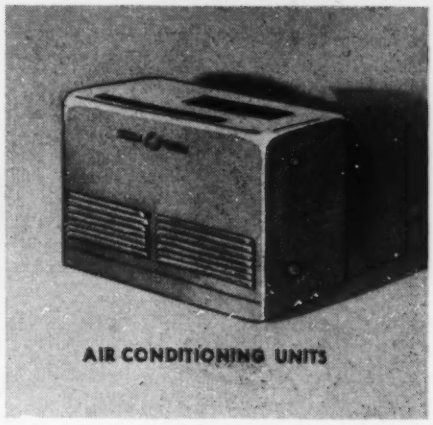
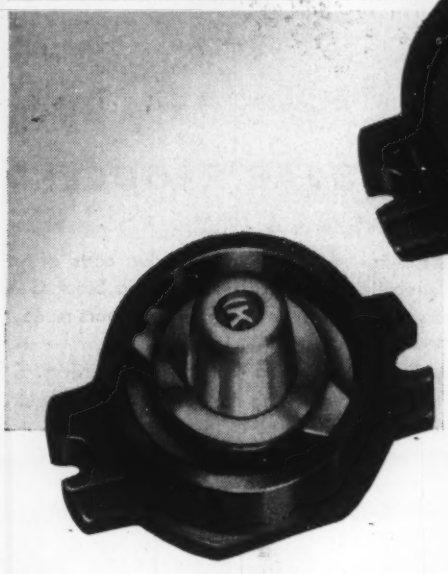
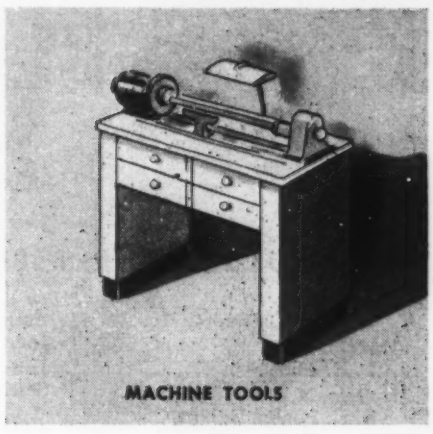

AIR CONDITIONING UNITS


AUTOMATIC RESET

MANUAL RESET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Assure Long Operating Life by Preventing Motor Burnouts in All Types of Equipment

No matter what the product — machine tools, electric appliances, adding machines, oil burners — you can help build user acceptance by using and specifying motors with built-in Klixon Protectors.

These foolproof devices keep motors operating by eliminating motor burnouts. They take into account the factors that cause motors to overheat and prevent them from burning out by cutting "off" the power when the temperature reaches the danger point. Then when the motor cools sufficiently, they snap "on" the power either automatically or by manual reset depending on the type of protector specified. And because Klixon Protectors are built-in by the motor manufacturer, you get a tested and proven combination of a motor and protector matched to each other assuring safe protection for the life of the motor.

As a user of electrical motors, it will pay you to insist on and buy motors with Klixon Protectors.

KLIXON

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You can make substantial reductions in the drive costs of your machines and equipment by standardizing on Ohio Stock Gears and Speed Reducers. They save you and your customers money in these 3 definite ways:

1. They **are** stock, saving the extra cost of special orders.
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Ohio Stock Gears are available in spur, helical, bevel, worm and worm gear types.

Ohio Stock Reducers include ratios from 10-1 to 3200-1; single reduction capacities from 10 HP to 1/6 HP; double reduction capacities from 6000 inch pounds to 25 inch pounds.

Check "Ohio Stock" for the advantages and savings possible on your machine and equipment.

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OHIO GEARS

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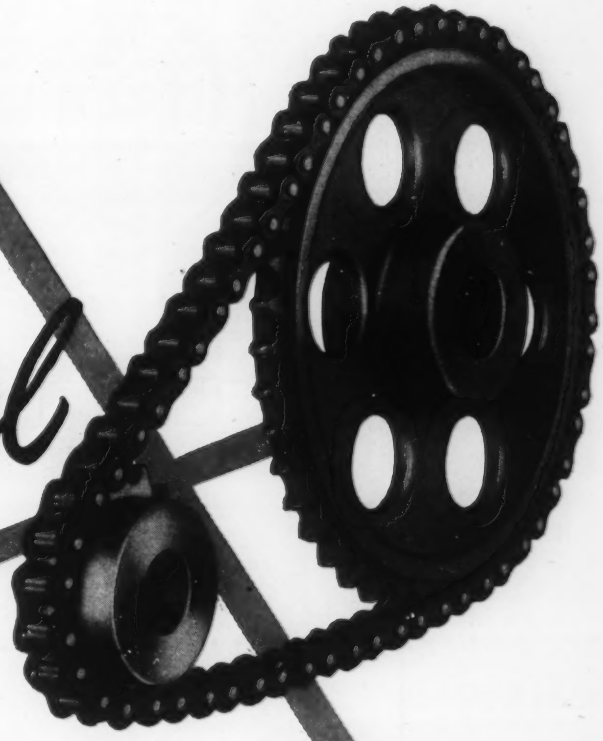


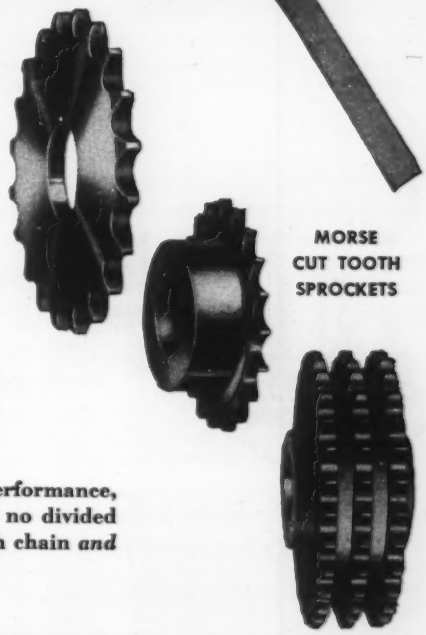
MORSE ROLLER CHAIN DRIVES

MORSE ROLLER CHAIN, made in American manufacturers' standard sizes, to standard dimensions as approved by the A.S.M.E and A.G.M.A., is *more* than standard in performance.

Its extra ruggedness, high efficiency, and dependable service have stamped it in the minds of designers and engineers as extra special for better mechanical power transmission.

Available in single and multiple widths, with pitches from 3/8" to 2½", Morse Roller Chain represents the result of engineering skill applied to a practical knowledge of chain design.

You get low-cost, positive, efficient, flexible chain drives for your mechanical power transmission with Morse Roller Chain. For complete information, write Dept. 338, Morse Chain Company, Detroit 8, Mich.



MORSE CUT TOOTH SPROCKETS

Morse Cut Tooth Sprockets, accurately machined for top performance, are recommended for use with Morse Roller Chain. There's no divided responsibility for chain drive performance when you get both chain *and* sprockets from Morse.

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MECHANICAL *POWER TRANSMISSION* PRODUCTS

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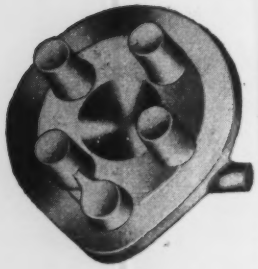
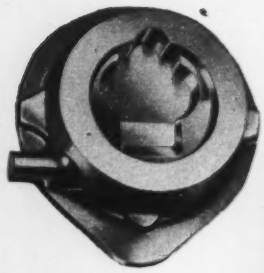
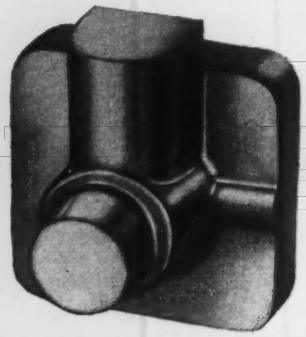
MORSE CHAIN COMPANY DETROIT 8, MICHIGAN

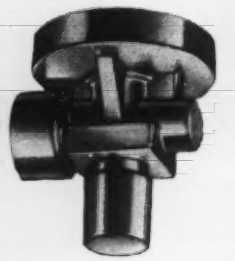




BRASS FORGINGS

are the answer where non-corroding, non-porous materials of great strength are essential



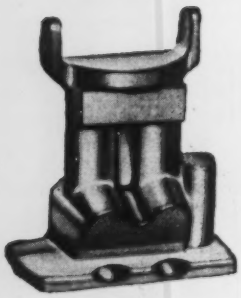


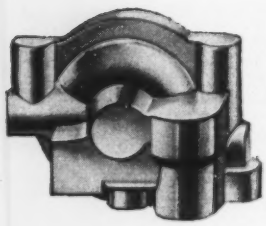
BRASS FORGINGS ARE SUPERIOR IN MANY WAYS TO SAND CASTINGS

LOWER COST: The combination of smoother surfaces, absence of porosity, better machinability, longer tool life, less chucking difficulty, closer tolerances, fewer operations, lighter weight, and practically no scrap, results in the production of a superior product at a lower cost.

Forgings possess about twice the tensile strength of sand castings. Extreme pressures under which the forgings are produced, once during extrusion and again during forging, assures a dense, close-grained material.

Due to the absence of scale, sand, etc. in the metal, forgings can be machined at a higher rate of speed than similar parts made by other processes, and the smoothness of surface, combined with close tolerances, frequently eliminates machining operations. The life of machine tools is greatly increased.



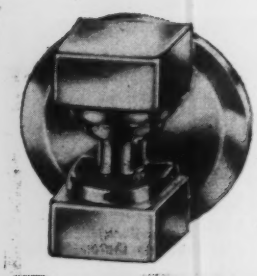


COMPARISON OF COST OF AVERAGE BRASS FORGINGS AND BRASS CASTINGS

(Quoted Figures are approximate)

Machined — Ready to polish, buff and plate	FORGINGS COST 20% LESS	
Polish and Buff	FORGINGS COST 50% LESS	
Scrap after Polishing and Buffing	CASTINGS 7%	FORGINGS 0

The Mueller Brass Co. is equipped to forge, completely machine, polish, buff, lacquer or plate. Let us quote you on your product in Forged Brass.



MUELLER BRASS CO.

PORT HURON, MICHIGAN

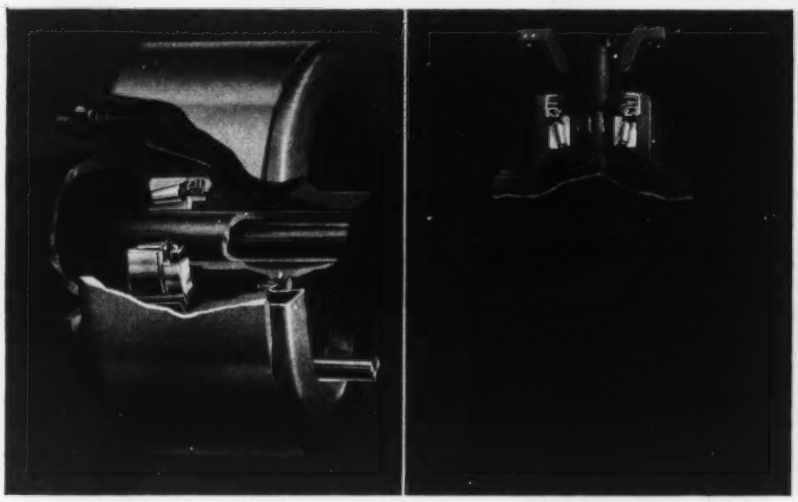
NATIONAL OIL SEAL LOGBOOK

PRACTICAL USE OF DUAL-WIPE LEATHER OIL SEALS

Heavy duty mechanisms operating under extreme dust and dirt conditions require two-fold protection of bearings and gears. Operating lubricant or fluids must be retained; harmful abrasives must be excluded from bearings and gear boxes. Many designers are answering this problem by specifying dual-wipe seals.

Typical of such seals are the National 10,000 and 30,000 Series oil seals. The 10,000 series (Fig. 1) is designed for moderate external dust conditions, speeds up to 2,000 F.P.M., and temperatures not exceeding 200°F. The 30,000 Series (Fig. 2) is designed for heavier abrasive conditions, speeds to 15,000 F.P.M., and temperatures not over 200°F.

Auxiliaries of felt are generally recommended for higher shaft speeds than are auxiliaries of leather.



Oil Seal, Rear Wheel — Oil Seal, Pinion

Figure 3

Both seal types are used in the heavy truck pinion and axle in Figure 3.

At the pinion, the problem was to retain lubricant, while excluding fine dust and grit from the mechanisms. A double-wipe seal was indicated, yet it had to be a seal whose exterior member could run "dry," at speeds up to 3,000 RPM. The National 10,000 Series seal answered the problem. Its spring-loaded inner sealing member, running under a pressure head of lube, maintains an effective seal despite high speed. The felt auxiliary effectively keeps out abrasive dust.

At the wheel position, the problem was to retain lubricant within the hub while excluding dirt churned up by the drive wheels. Since speeds were low and the main sealing member could operate under well lubricated conditions, a National 30,000 Series seal proved effective. The spring-loaded main member retains wheel lube, while the dry-running leather flange keeps out abrasives.

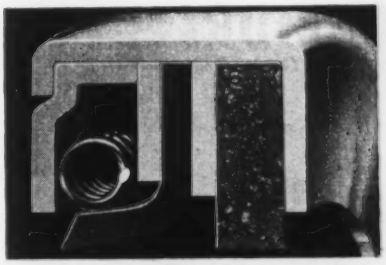


Figure 1

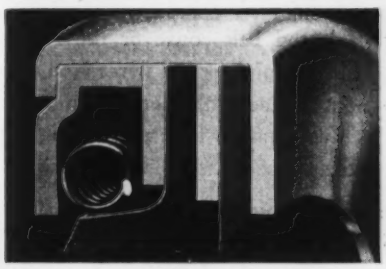


Figure 2

Oil seals such as these two National types are generally preferred for applications where speeds are low, such as trucks over 1½ tons, tractors, farm implements and road equipment. When speeds and temperatures beyond those discussed are encountered, synthetic seals will solve the problem. When extreme conditions exist, a special design may be necessary.

For additional information about dual-wipe seals in your product, ask the nearest National Oil Seal Engineer or write direct.

NATIONAL
OIL AND FLUID SEALS ®

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, California
Plants: Redwood City and Los Angeles, California; Van Wert, Ohio

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

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CHICAGO: Room 2014 Field Building, Central 6-8663.
CLEVELAND: 210 Heights Rockefeller Bldg., Yellowstone 2720.
DALLAS: 30½ Highland Park Village, Justin 8-8453.
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HOUSTON: 6731 Harrisburg Boulevard, Wayside 3-1246.
LOS ANGELES: 2244 East 37th Street, Kimball 6384.
MILWAUKEE: 647 West Virginia St., Marquette 8-8986.
NEW YORK CITY: 122 East 42nd Street, Lexington 2-8260.
PHILADELPHIA: 401 North Broad Street, Bell-Walnut 2-6997.
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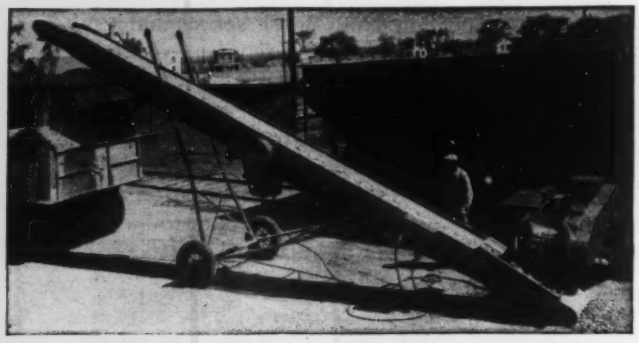
EAST SYRACUSE, N. Y.: 226 Roby Avenue, East Syracuse 366.
WICHITA: 340 North St. Francis Ave., Wichita 2-6971.

CONE-DRIVE
(DOUBLE ENVELOPING GEARING)

Compact Gearing with 5 HP Motor Starts RR Car Unloader Under Full Load

BARBER-GREEN COMPANY, Aurora, Illinois, has provided its new Model 358 Hopper-bottom Car Unloader with a powerful yet compact drive mechanism which will start the cleated belt conveyor moving even though fully loaded. This eliminates the heretofore necessary practice of digging out a Car Unloader which has become stalled in operation due to power failure or other stoppage. This applies whether the Unloader is operated over or under the rails.

Designed for unloading both abrasive and non-abrasive materials from Hopper Bottom cars, the unloader is belt driven through a standard 10-to-1 ratio Cone-Drive geared speed reducer of only 3" center distance by a 5 h.p. gasoline engine with an input speed to the reducer of 1150 rpm. The exceptionally high load carrying capacity of this type gearing is illustrated by the fact that the same size conventional type right angle speed reducer would handle less than 2 h.p.



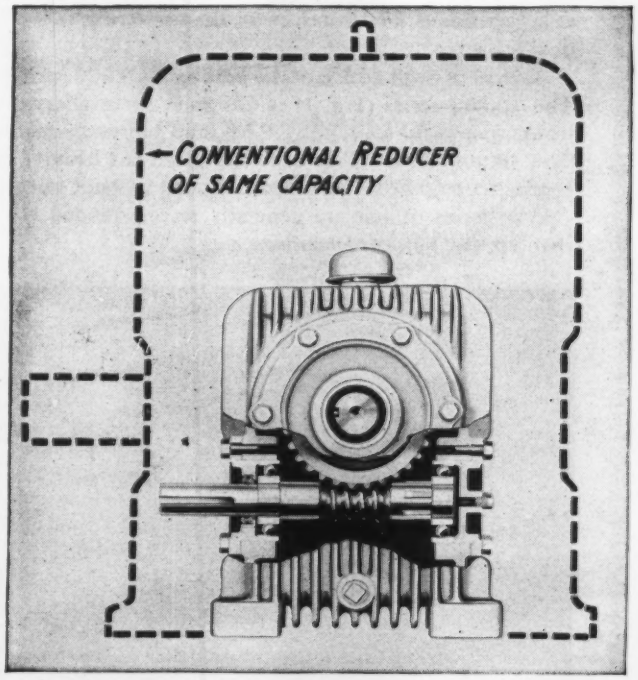
The Barber-Greene car unloader in operation.

Ruggedness, light weight and compactness of the Cone-Drive gearing are due to its "double enveloping" characteristics produced by a special gear cutting process. This gives more teeth in contact and greater contact per tooth. The load is therefore distributed over a larger total tooth area.

Major specifications of the reducers used by Barber-Greene are:

Type: Standard Cone-Drive Model SU-7310
Ratio: 10 to 1
Center Distance: 3 inches
Rated Capacity: 4.88 h.p. at 1150 r.p.m.
Service: 8 to 10 hours per day
Cooling: Finned; natural convection
Overall Dimensions: 9⅜ by 6⅞ by 12¼ inches.

For further information on Cone-Drive geared speed reducers, write Michigan Tool Company, Cone-Drive Division, 7171 E. McNichols Road, Detroit 12, Michigan.



Above — Comparative size of the Cone-Drive reducer and a conventional reducer of the same capacity.

Below — Finned cooling of the Cone-Drive speed reducer boosts load carrying capacity.

COUNT ON VEEDER-ROOT

Mechanically...

Strokes, revolutions, pieces, volumes, lengths . . . or other units of performance and production . . . can be counted by Veeder-Root Mechanical Counters like this new General-Purpose No. 1260. This direct-reading, streamlined counter counts up to 1,000,000 . . . then resets (unless you want to reset it sooner) with one turn of knob. And it's *compact,* so it can be ***built into*** most machines and products, to add utility and marketability.

Magnetically...

To report machine output direct from plant to office . . . or to count units of a size or weight that makes them tough to count mechanically . . . count on these new Veeder-Root Reset Magnetic Counters, No. 1205 for AC, No. 1248 for DC. Easy to install on regular light circuit . . . widely used with "electric eye." And they may be grouped on panels, at any distance from the machines they report on.

Manually...

To count people, poles, shrubs, blood-corpuscles, cars, ticket-buyers . . . or anything that can't be counted mechanically or magnetically . . . count on this No. 1023 Hand Tally that fits both hand and pocket. To count one, press thumb-lever once. When count is complete, turn reset knob, start over from zero. Ends errors from memory-count and pencil tallies.

These are only 3 of the scores of types of Veeder-Root Standard and Special Counters. Most likely you, too, can count on Veeder-Root, to your profit. Write.

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VEEDER-ROOT INCORPORATED
HARTFORD 2, CONNECTICUT
In Canada: Veeder-Root of Canada, Ltd., 955 St. James St., Montreal 3.
In Great Britain: Veeder-Root Ltd., Kilspindie Rd., Dundee, Scotland

Bundyweld*... your best call for tubing

Like to get a line on better design, faster production, lower costs or higher quality in your tubular applications?

Put in a call for Bundyweld* Tubing!

Double-walled from a single strip, bonded throughout, Bundyweld is lightweight, ductile . . . leakproof, too . . . and can be bent without fear of collapsing or weakening structurally. Held to close tolerances, it can be easily machined or fabricated . . . cuts production time, lowers production expense.

Manufacturers in many fields . . . automobile, machine tool, range, television, radiant heating, refrigeration, tubular toys—to mention only a few . . . are ringing in on the advantages of low-cost Bundyweld Tubing.

Chances are, your design, structural or functional problem can be solved by this miracle tubing of industry, even though you may not seem to need a tubing at all. Why not give it a try? Contact your near-by Bundy representative among those listed below, or write direct to: *Bundy Tubing Company, Detroit 14, Michigan.*

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ENGINEERED TO YOUR EXPECTATIONS

* REG. U.S. PAT. OFF. ®

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1 Bundyweld Tubing, made by a patented process, is entirely different from any other tubing. It starts as a single strip of basic metal, coated with a bonding metal.

2 This strip is continuously rolled twice laterally into tubular form. Walls of uniform thickness and concentricity are assured by close-tolerance, cold-rolled strip.

3 Next, a heating process fuses bonding metal to basic metal. Cooled, the double walls have become a strong ductile tube, free from scale, held to close dimensions.

4 Bundyweld comes in standard sizes, up to 5/8" O.D., in steel (copper or tin coated), Monel or nickel. For tubing of other sizes or metals, call or write Bundy.

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National Lock Co.
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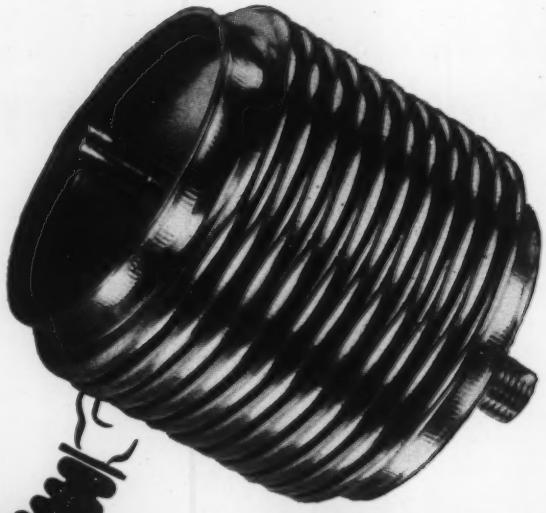
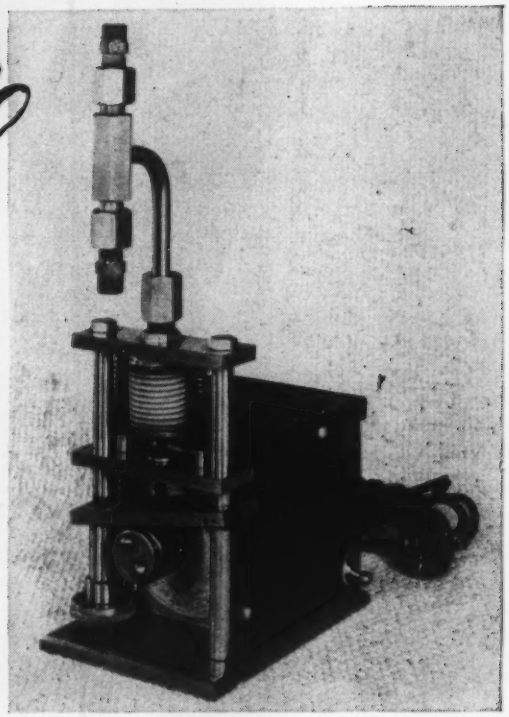


with CMH Stainless Steel Bellows

Skilled personnel at CMH know the importance of uniformity and rigid adherence to specifications in the successful operation of your product. And the extra care they put into the fabrication of CMH Bellows and Bellows Assemblies is your assurance of securing the best possible performance.

For vacuum equipment, thermostatic devices, pressure controls, valves, recording instruments, hydraulic mechanisms, rotating shaft seals and scores of other applications, CMH Stainless Steel Bellows offer the following advantages — corrosion resistance . . . high and low temperature accommodation . . . uni-metal assemblies . . . standardized production economies . . . multiple ply construction when required.

Ask for complete information on how CMH Stainless Steel Bellows can be used in your product. Literature and data sheets giving detailed technical data and application information are also available on request.



A CMH Stainless Steel Bellows is used in this laboratory bellows pump manufactured by the Research Appliance Company.

CMH—ONE dependable source
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• CMH manufactures all standard types of flexible metal hose, both convoluted and corrugated, in a variety of metals; expansion joints for piping systems; stainless steel and brass bellows; various conduits and special assemblies of these components.

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from

GENERAL ELECTRIC

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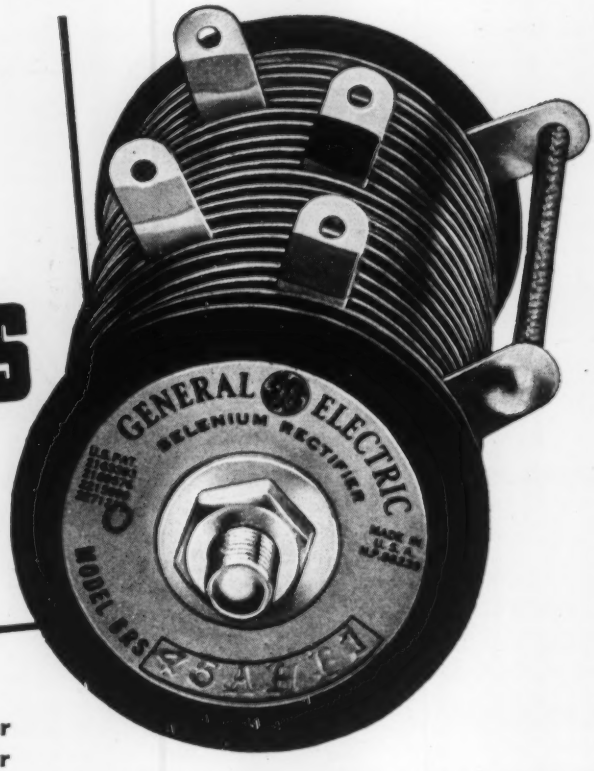
using

NEW 18-VOLT (D-C) CELLS



New process for depositing selenium means greater uniformity, higher efficiency and longer useful life for rectifier stacks.

Here's real news for rectifier users. It's the new G-E 18-volt selenium cell—made by a patented evaporation process which deposits selenium on the aluminum base with greater uniformity than otherwise possible.

Greater Output — These new cells have a 50 per cent greater output than standard 12-volt cells. And—they can be used for any application except those few which demand 24-hour year-around service.

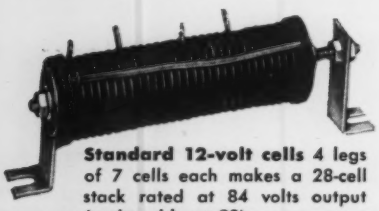
Efficiency Stays Up — Not only is initial efficiency higher but, with the more uniform coating, high efficiency is maintained.

Save Space — These new 18-volt cells require about one-quarter less space than standard 12-volt cells for the same output.

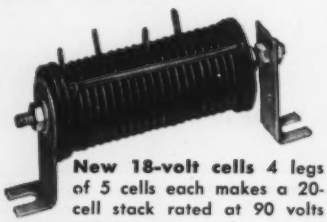
Lower Cost — Depending on the voltage, these 18-volt cells save 25 per cent in cost compared to standard 12-volt cells.

You'll need more information. There's a free bulletin awaiting you. Ask for it as GEA-5280, *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

HERE'S A COMPARISON—full-wave bridge rectifiers



Standard 12-volt cells 4 legs of 7 cells each makes a 28-cell stack rated at 84 volts output (and usable at 90)



New 18-volt cells 4 legs of 5 cells each makes a 20-cell stack rated at 90 volts output.

Applied a-c volts	Rated d-c volts	Actual d-c volts new	Actual d-c volts aged	Size available d-c amps
26	18	20.5	18	0.25
				0.50
23		18	16	1.20
52	36	41	36	0.25
				0.50
46		36	32	1.20
78	54	61.5	54	0.20
				0.50
69		54	48	1.00
104	72	82	72	0.20
				0.50
92		72	64	1.00
130	90	102.5	90	0.20
				0.40
115		90	80	1.00
156	108	123	108	0.20
				0.40
138		108	96	0.80
182	126	143.5	126	0.15
				0.35
161		126	112	0.80

The d-c voltages are given for both new and estimated aged conditions. On applications where a variation in d-c voltage can be tolerated, a fixed a-c voltage can be applied—a gradual decrease in d-c voltage, as given in the third column, can be expected. On applications requiring constant d-c voltage, it will be necessary to adjust the voltage of the a-c input—the range given in the first column will give the rated d-c output shown in the second column.

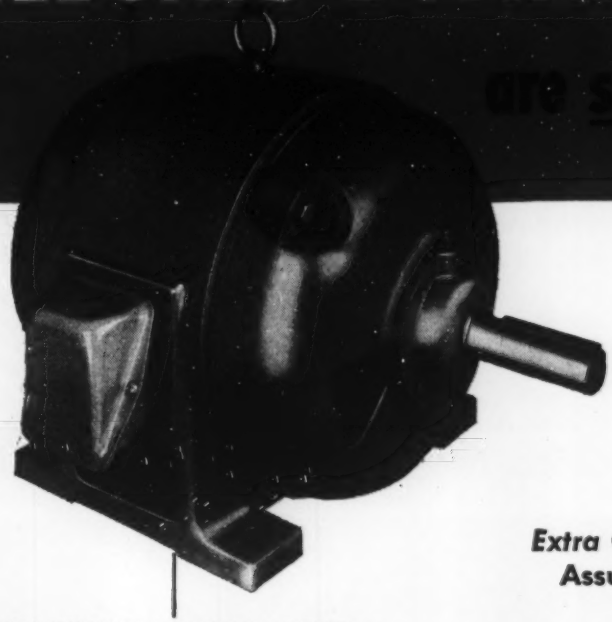
GENERAL ELECTRIC

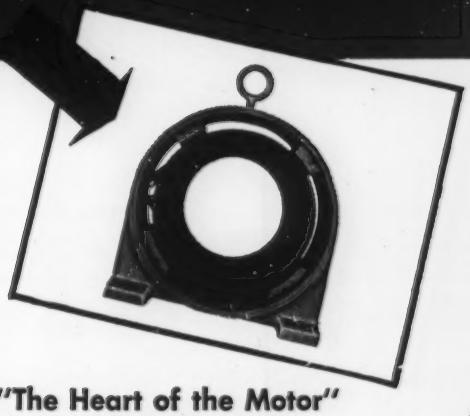
456-10

Look at the WINDINGS and See for Yourself . . .

ELECTRO DYNAMIC MOTORS

are stout-hearted motors!





ELECTRO DYNAMIC INDUSTRIAL MOTORS are built in a wide range of types and sizes . . . 1 to 250 H.P. Shown above is an E.D. Drip Proof Industrial Motor. For use under ordinary industrial conditions not requiring protection from splashing liquids or from atmosphere laden with dirt or metal chips.

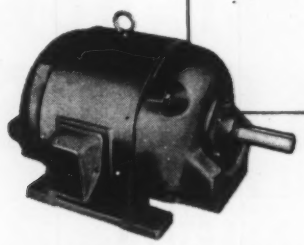
Extra Care at "The Heart of the Motor" Assures You Longer Service, Greater Operating Dependability

Every E.D. industrial motor receives specialized attention at the windings —"the heart of the motor." This extra care and superior insulation materials give Electro Dynamic motors the *plus qualities* of great reliability and long life.

E.D. motors have long been known for staunch dependability in the toughest of all power installations—aboard great ships at sea, under unbelievably severe operating conditions. Now the fine craftsmanship and sturdy construction features of these famous E.D. marine units have been incorporated in a versatile new line of E.D. *industrial* motors, designed to bring to *your* electric power installations the same stamina and trouble-free performance that have characterized E.D. products since 1880.

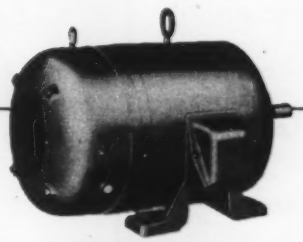
Get the facts on Electro Dynamic industrial motors. You'll be amazed that such rugged, carefully made motors can be *competitively priced!* Write today for illustrated literature.

Other Types of ELECTRO DYNAMIC Industrial Motors



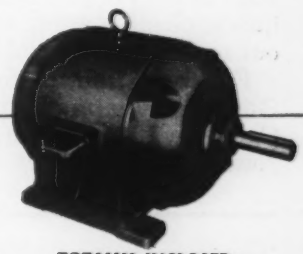
SPLASH PROOF

For installation where the motor is subjected to splashing liquid or hosing down for cleaning.



TOTALLY INCLOSED (Fan-Cooled)

For dirt-laden atmospheres, especially where the installation requires a motor of compact dimensions.



TOTALLY INCLOSED (Non-Ventilated)

For use in exceptionally dirty atmospheres, particularly when metallic dust is present.

Also a Complete Line of DIRECT CURRENT Motors and Generators. Literature on Request.

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ELECTRO DYNAMIC

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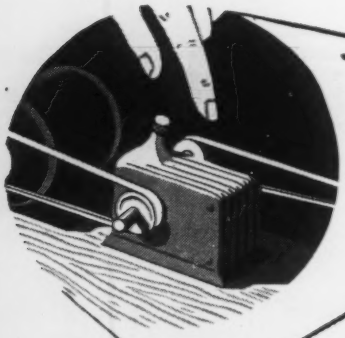
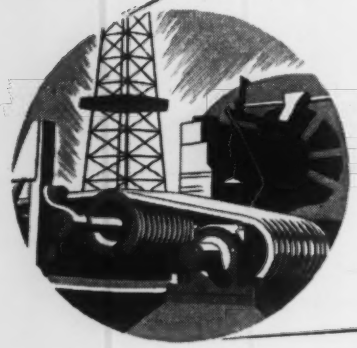
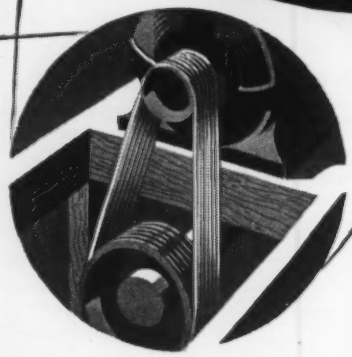


Do You Have a Problem in TURNING WHEELS?





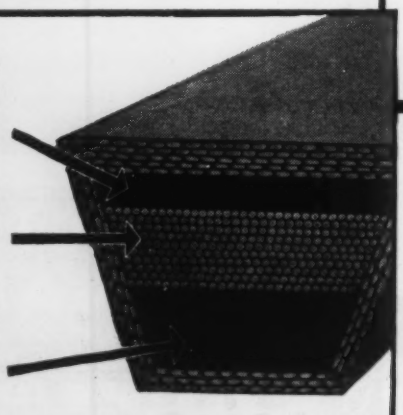
Maybe you have a job that you never dreamed could be done with a V-belt. Perhaps we at U. S. Rubber can help—we are constantly solving such problems . . . sometimes by designing V-belts which help safeguard human life—on submarines, for example.

U. S. Rubber engineers have designed a V-belt as small as 4¾ inches in circumference, and as large as 55 feet. They have solved such a wide range of V-belt problems that today, if you want "a special" in a hurry, chances are it can be obtained without making a new mold.

For more information, write Mechanical Goods Division, United States Rubber Company, 1230 Avenue of the Americas, New York 20, N. Y.

U. S. RAINBOW V-BELTS

WITH THE EQUA-TENSIL CORD SECTION



Top Rubber Cushion in closely-engineered balance with the lower section . . . to keep cool under constant stretch and turn.

Equa-Tensil Cord Section —all cords scientifically placed, each pulling its share of the load.

A sturdy level cushion for the Equa-Tensil Cord Section. Provides structural firmness for V-grooves and over the flat pulley of V-to-flat drives.

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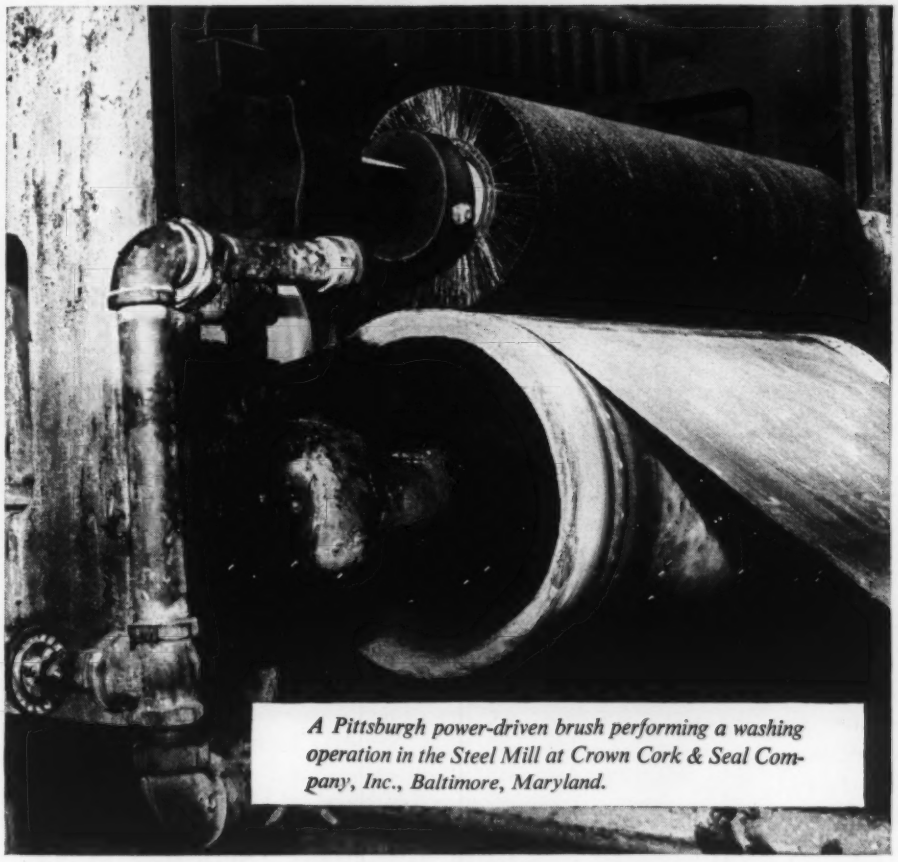
UNITED STATES RUBBER COMPANY

"PITTSBURGH" *Power Driven* BRUSHES



A Pittsburgh power-driven brush performing a washing operation in the Steel Mill at Crown Cork & Seal Company, Inc., Baltimore, Maryland.

On the job for...

CROWN CORK & SEAL

Pittsburgh's ability to cope with difficult brush problems solved a cleaning operation for Crown Cork & Seal Company, Inc. Oil film collected on the steel during the rolling process and had to be thoroughly removed before the steel was annealed.

Pittsburgh's skilled engineers studied the problem then designed a "built-up" brush roll of Tampico Sections. It was just the brush needed for the job . . . *stiff* enough to remove all oil and foreign matter . . . *soft* enough not to impair surface texture . . . *tough* enough to withstand the wear.

Whether your particular brush problem is cleaning, roughing, finishing or polishing— you can rely on the ingenuity of Pittsburgh's engineers to design a brush to do the job right. And Pittsburgh brushes will save you time and money!

There's a "Pittsburgh" Brush for Every Industrial Use!

- GLASS
- STEEL
- PLASTICS
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- RUBBER
- PAPER
- TIRE and RETREADING
- SHOE MANUFACTURING and REPAIRING

In the complete Pittsburgh line are brushes of all types, including "Perfect Balance" sections, wheels and assemblies. Consult the Pittsburgh engineering representative. He will gladly work with you in developing any type of power-driven brushes to meet your particular finishing specifications.

Phone or write Pittsburgh Plate Glass Company, Brush Division,
3221 Frederick Ave., Baltimore—29, Maryland

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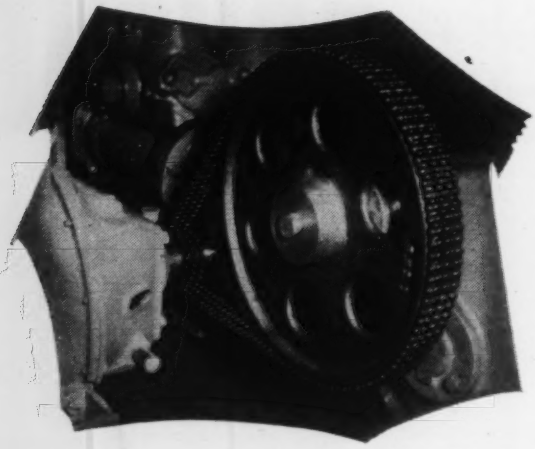
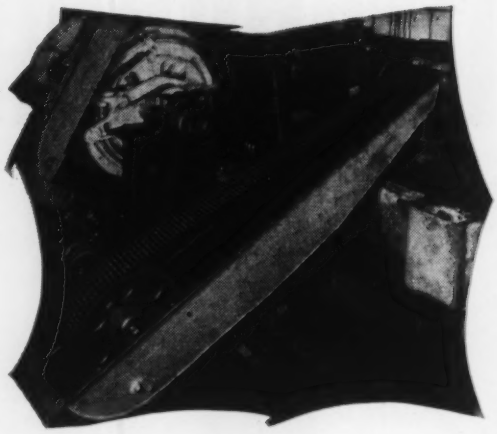
PITTSBURGH PLATE GLASS COMPANY



Triple Diamond Roller Chain (short-center) Drive from 20-tooth to 102-tooth sprockets.



Sextuple Diamond Roller Chain (long-center) Drive from 25-tooth to 69-tooth sprockets, on construction crane.

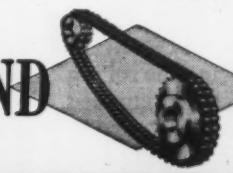
For Long or Short Centers

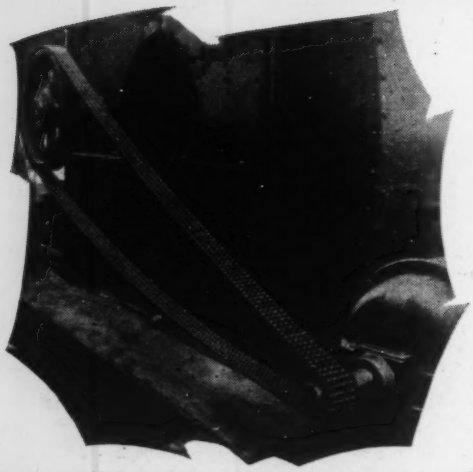
Diamond Chains Are Equally Effective

Center distances present no problems when you use Diamond Roller Chains and Sprockets. High speed ratios, even on short centers, are effectively handled and without slipping because the chain remains in mesh with the sprocket teeth.

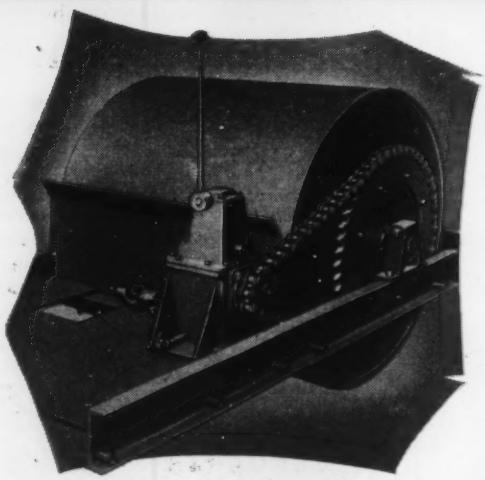
On long centers too, Diamond Chain Drives are as positive as gears yet do not involve the great weight, cost, and maintenance of gears large enough to span long shaft centers.

Because there is no separating force as with gears, and no tension as with belts, bearing life is lengthened. Diamond Roller Chains will improve the performance of machinery — save power and reduce upkeep. Diamond Roller Chains facilitate design and are easy to install, — they are quiet, resilient, easily serviced. DIAMOND CHAIN COMPANY, Inc., Dept. 435, 402 Kentucky Avenue, Indianapolis 7, Indiana. *Offices and Distributors in All Principal Cities.*

DIAMOND  **ROLLER CHAINS**

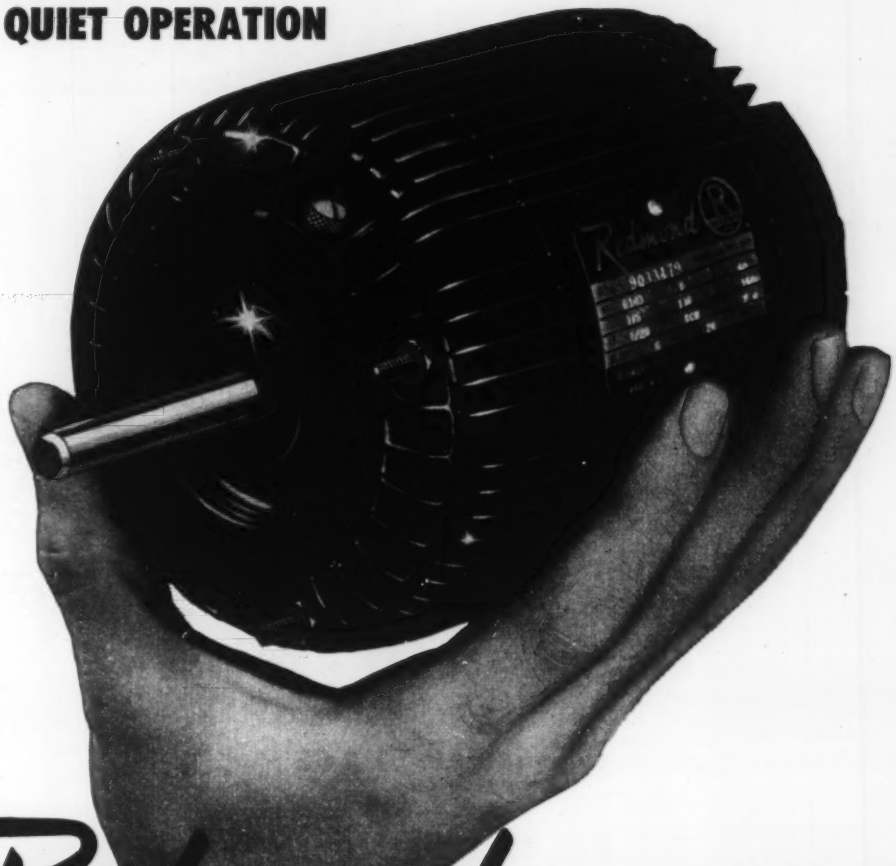


Quadruple Diamond Roller Chain (long-center) Drive operating ventilating fan running from 20-tooth to 114-tooth sprockets on 6'6" center.



Single Diamond Chain (short-center) Drive on transmission of 3-4 ton size variable weight Tandem Roller.

PRECISION-BUILT BY SPECIALISTS FOR SMOOTH, QUIET OPERATION



Redmond MICROMOTORS

Over 140 Standard Models . . . 23 Different Types
A.C. or D.C. up to 1/10th Horsepower

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BLOWER 3866: 150 C.F.M., A.C., With Single Air Outlet

Get your hands on a Redmond Micromotor . . . any model, any type to suit your particular application. You'll like the solid, substantial "feel" of it . . . the apparent fine care with which it was assembled and finished. You'll approve its smart, crisp appearance . . . its sturdy, rugged construction. And, as you check its details point for point against your own low-range power requirements, you'll fully appreciate the many advanced engineering features that have been incorporated in its design. They're precision features developed by Redmond small motor specialists to give you smoother, quieter operation and maximum long-life performance at minimum cost.

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Write today for the complete Redmond Catalog covering AC and DC MicroMotors, blowers, and speed controllers.

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EXPANDED FACILITIES • PROMPT DELIVERIES • SERVICE BEFORE AND BEYOND THE SALE

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all Packaged!

LET US HELP YOU TO:

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Costs are of daily increasing importance to you. We'd like to talk to you about the advantages that can be obtained in efficient packaging of engine bearings for your service requirements. Your inquiry will receive prompt attention.

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NO We're Not Quite That Good But We Are Getting Closer Every Day!

Sounds ridiculous that tolerances can be held to the "Nth degree" . . . but at General Plate we are getting closer to it every day because it has become increasingly important that thermostat metals be accurately rolled. In fact, one of our customer's "specs" calls for Truflex Thermostat Metal with a tolerance ± .00005, . . . and through our high precision-manufacturing process, we are meeting it with every delivery.

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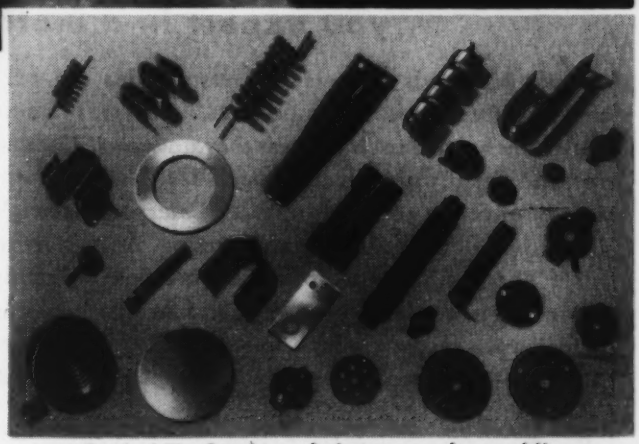

Typical Truflex formed elements and assemblies.

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Please send me information on Truflex Thermostat Metals.

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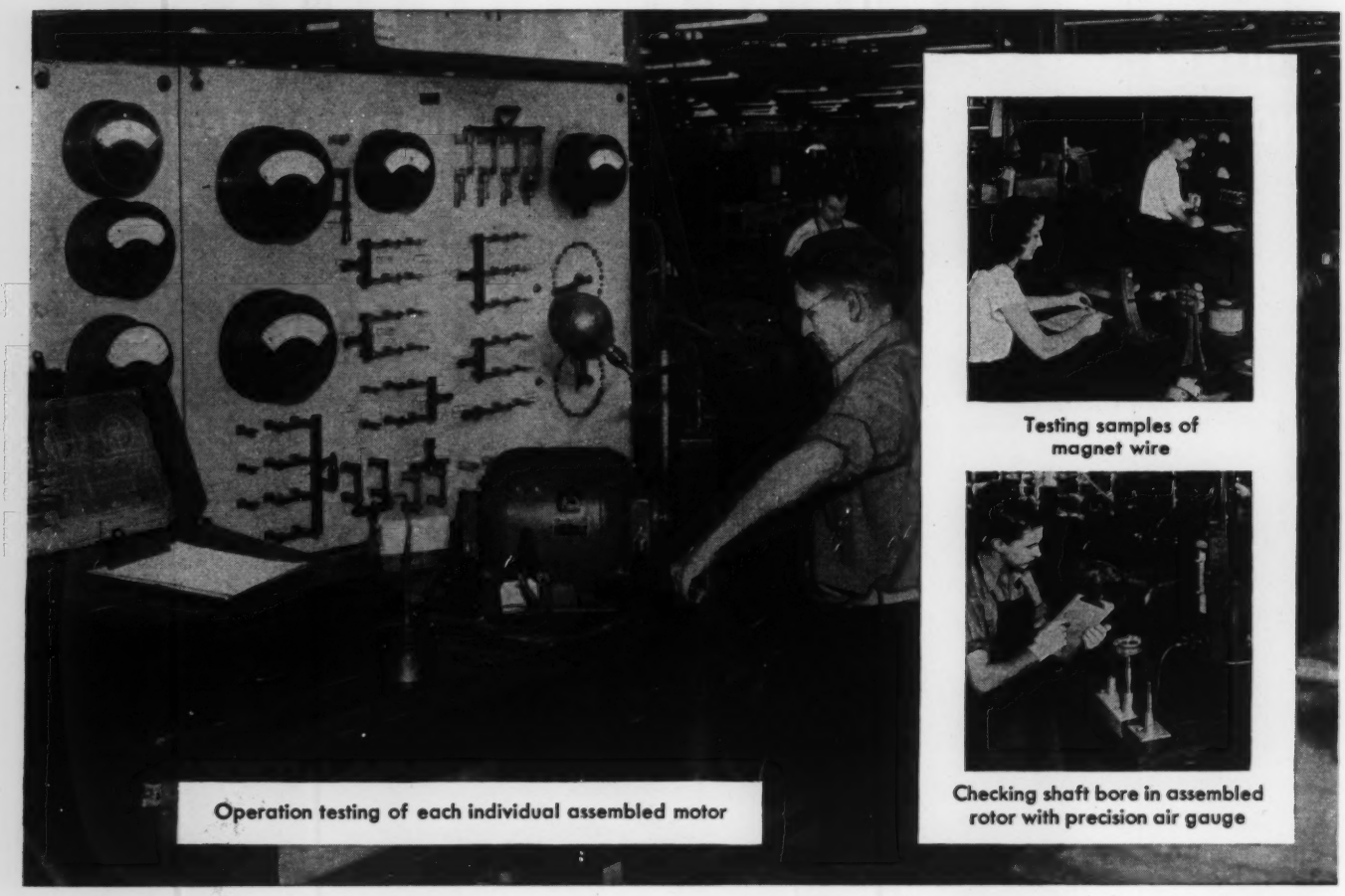
I-449

INSPECTION... QUALIFICATION... PERFECTION!



Operation testing of each individual assembled motor

Testing samples of magnet wire

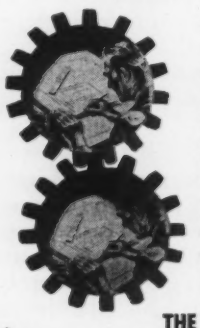
Checking shaft bore in assembled rotor with precision air gauge

Exacting tests maintain the high performance standards you expect in a motor that's *Twin-gineered*

Literally hundreds of tests and inspections are performed on *all* motor components . . . to *prove* their quality anew with each process they undergo. Trained eyes, and a huge investment in specialized testing equipment of uncanny accuracy, enforce Emerson-Electric's philosophy of precision manufacturing, from start to finish. The results show up in the rigid final assembly tests of the completed motor . . . and in the enviable performance records which Emerson-Electric motors have achieved in a wide range of equipment applications.

Rigid *Quality Control* is only one of many advantages assured in Emerson-Electric's uniquely successful *Twin-gineering* system. Your inquiry is invited.

Here's how TWIN-GINEERING *"follows through"* to give you a money-saving motor drive:



- **DESIGN SERVICE:** Our "draft board," in consultation with your engineers, plans the best motor drive for your product.
- **PRODUCTION:** An Emerson-Electric Application Engineer, assigned to each project, directs the writing of specifications and performance requirements, from which production is planned.
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- **FIELD LIAISON:** Our Territorial Representative provides direct liaison on all phases from inception to final delivery and marketing of the product.

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EMERSON ELECTRIC

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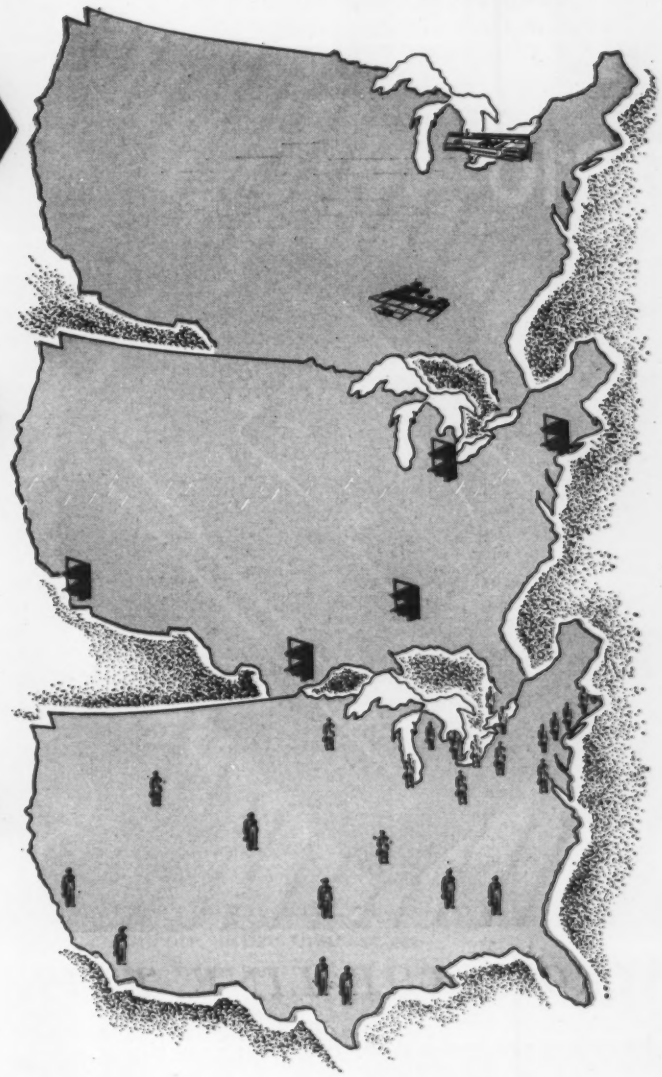
—scattered over the country in convenient locations ready to assist you with your tube problems



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Remember, Wolverine non-ferrous tube is seamless—and quality controlled from ore to finished product.

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ARROW-H&H

Small Motor Starting Switches

7810

6808

ACROSS-THE-LINE TYPE without overload protection

Everywhere relied upon to give positive control of motors; especially suitable for oil burners, refrigerators, motor-driven machinery and lighting loads.

These switches have rugged, durable mechanisms built to perform with the sturdy integrity characteristic of Arrow-H & H Lines. Bakelite arc snuffers increase breaking capacity; kick-off release mechanically starts the switch blades in motion and prevents sticking; extra-heavy blades and contact jaws increase current-carrying capacity. Different styles of mounting are supplied for a wide range of machine-design requirements. Separate switch units are available for installations in switch housings built into motor-driven machinery.

No. 6808 (upper and lower right) is a double-pole switch for single phase motors; No. 7810 (upper and lower left) is 3-pole for 3-phase jobs. 7810 combines greatly increased mechanical life with *small size:* — 4 1/16″ high, 2 11/16″ wide, 2 15/16″ deep over all. The line includes 3-way, 4-pole and 2-speed reversing switches. All have horsepower ratings... Everything you may need in this line will be found in Motor Control Catalog No. 10 — on request.

AH

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Enduring Precision
This spindle bearing is standard equipment on large spindles designed by a world-famous builder of precision grinders. For extreme accuracy, for freedom from vibration, and for enduring precision, only sleeve bearings will do. Where other types of bearing retain their accuracy only for months, Bunting Spindle Bearings endure for years. Where other complex types require a surgical standard of cleanliness and a watchmaker's skill for replacement, the Bunting Sleeve Bearing requires only common-sense and the services of a good mechanic.
The secret of this performance and long life lies in the film type of lubrication. A properly designed and well lubricated sleeve bearing need not acknowledge any superior. No other bearing type possesses its simplicity, its ruggedness, its ability to deliver accurate work for many years. These attributes are possessed by the sleeve bearing.
Bunting engineers are at your service whether your problem is a precision grinder spindle, an aircraft engine, an automobile engine, or something of more or of less exacting requirements. Bunting engineers utilize their extensive experience with bearings of all types in their work of designing Bunting Cast Bronze Sleeve Bearings.
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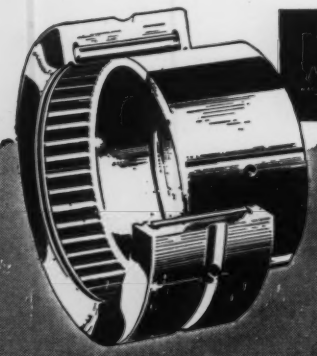
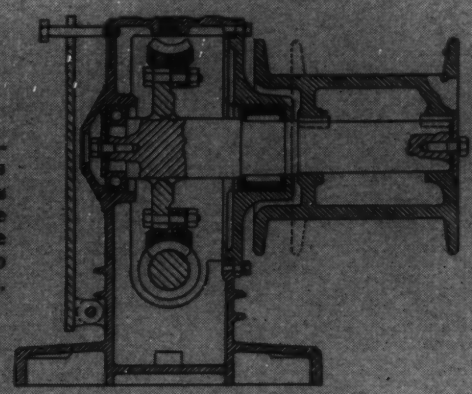
76

design anti-friction efficiency into out-moded plain bearing applications

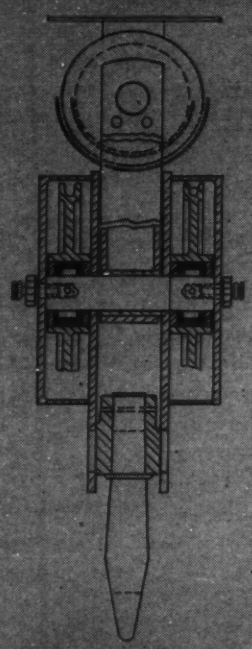
THE *MULTIROL* WAY

When design demands maximum load capacity in limited space . . . plus top anti-friction performance . . . get results with MULTIROL SE Series full type roller bearings. MULTIROL SE Series bearings afford definite performance advantages over friction bound plain bearings. They increase machine efficiency with the kind of smooth precision operation that requires less maintenance for longer machine life — power requirements are less for MULTIROL bearing equipped machinery. SE Series construction is simplified . . . no loose or welded in roller retaining washers . . . lubrication reservoir built in. Smaller radial bearing space with increased load capacity permits more compact and less expensive housing facilities. All add up to improved anti-friction performance. Use with or without inner race in shaft sizes from ⅜" to 9¼". Write for data now!

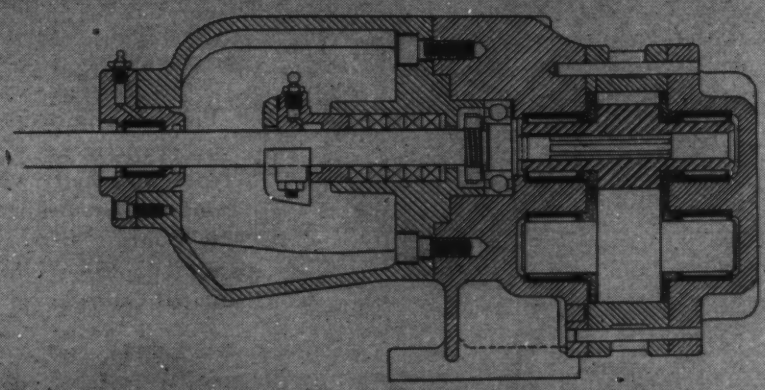




In typical capstan application MULTIROL SE Series maximum capacity bearings fit the small space under the cable drum, yet accept large diameter shaft necessary to carry heavy overhung load.



Use MULTIROL SE Series bearings on sheaves for maximum shaft diameter of pin and minimum housing OD . . . increases load capacity. Lubrication with Alemite fittings need less care than oil bath with plain bearings.



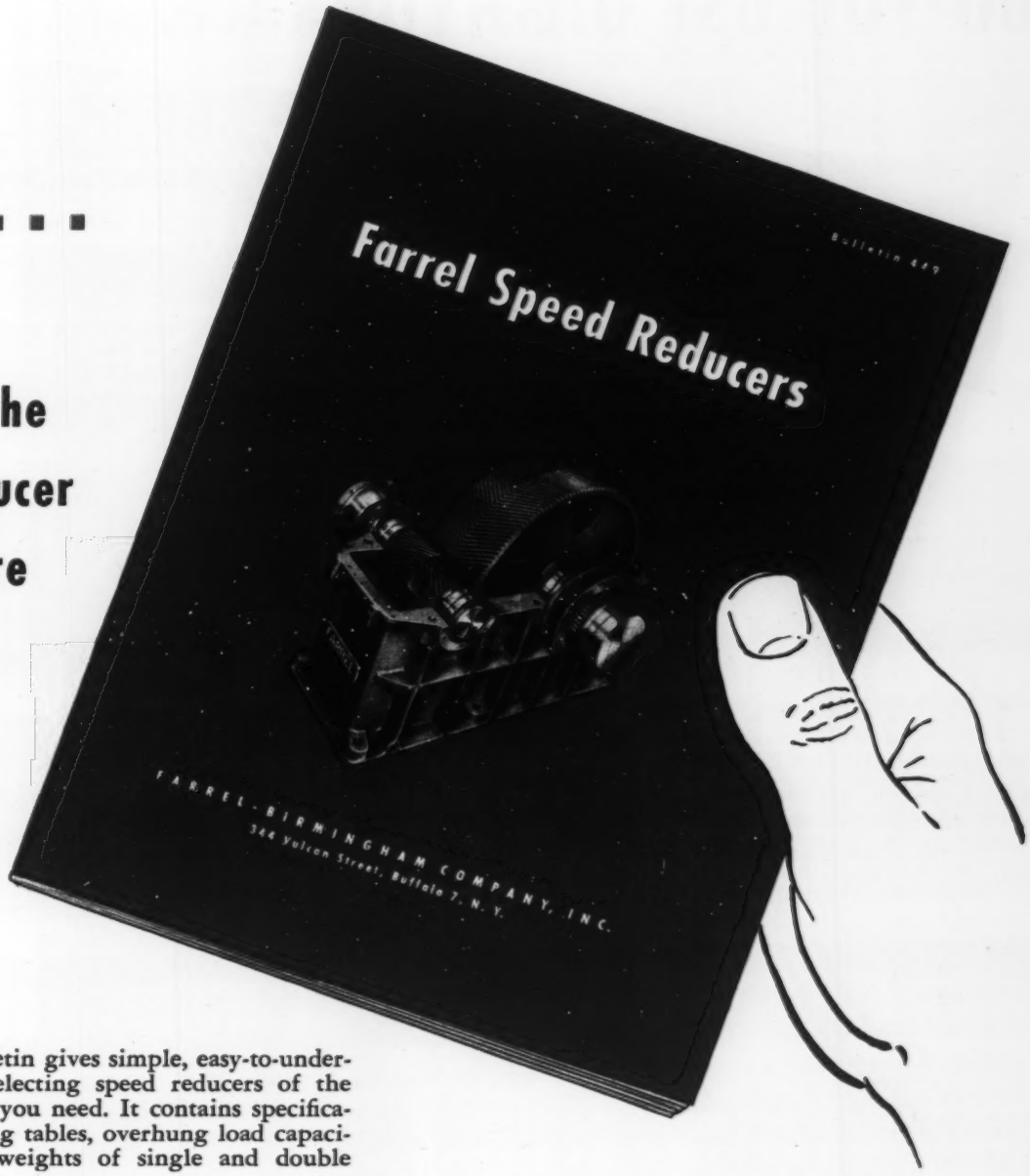
On a rotary gear pump, the heavier load capacity and comparatively small OD of SE Series MULTIROL Bearings permits use of larger shaft that resists deflection. Precision anti-friction requires less power imput.

Interested in SE Series MULTIROL bearing advantages? Write today for your copy of Bulletin SE-48. McGill Manufacturing Co., Inc. 200 N. Campbell St., Valparaiso, Indiana

McGILL
TRADE MARK
precision bearings

NOW...

it is easy to select the speed reducer you require



This *new* 44-page bulletin gives simple, easy-to-understand directions for selecting speed reducers of the horsepower and speed you need. It contains specifications, horsepower rating tables, overhung load capacities, dimensions and weights of single and double reduction units.

These reducers are equipped with Farrel-Sykes continuous-tooth, herringbone gears—the famous *Gear with a Backbone* — which provide extra strength and high load-carrying capacity. Because they are generated with a high degree of precision, these gears are extremely quiet in operation and give many years of trouble-free service.

Other features described in the bulletin, which contribute to smooth, efficient power transmission, include rigid and accurately ground shafts properly mounted in roller bearings, and heavy-section cases that hold rotating elements in precise alignment.

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Plants: Ansonia and Derby, Conn.; Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Detroit, Chicago, Los Angeles, Tulsa, Houston

Farrel-Birmingham

If you buy or specify speed reducers, you should have a copy of this handy manual. Fill out the coupon and drop it in the mail today.

FB-501

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Farrel-Birmingham Co., Inc., 344 Vulcan St., Buffalo 7, N.Y.

Please send me, without cost or obligation, a copy of Bulletin 449, "Farrel Speed Reducers."

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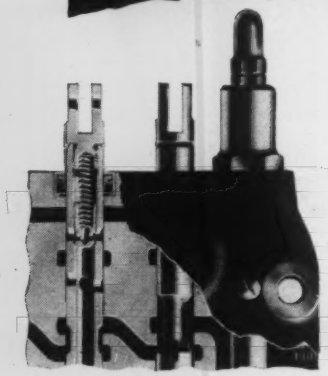
DO YOU USE OIL-HYDRAULICS?

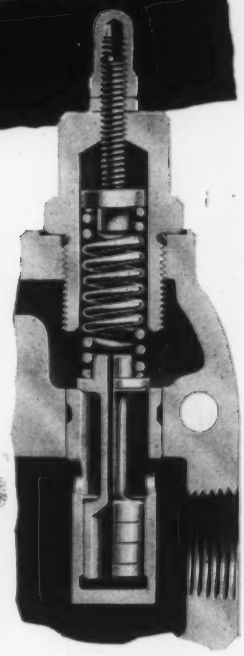
...then check these features of HYDRECO HOLLOW PLUNGER* VALVES

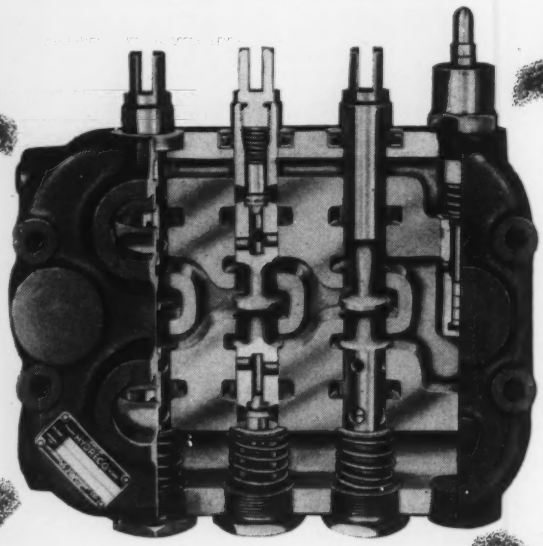


- Specifically designed for industrial oil-hydraulic systems.

More than fifteen basic models for controlling one or more single and double-acting cylinders.

For systems operating up to 1000 PSI to 1400 PSI.



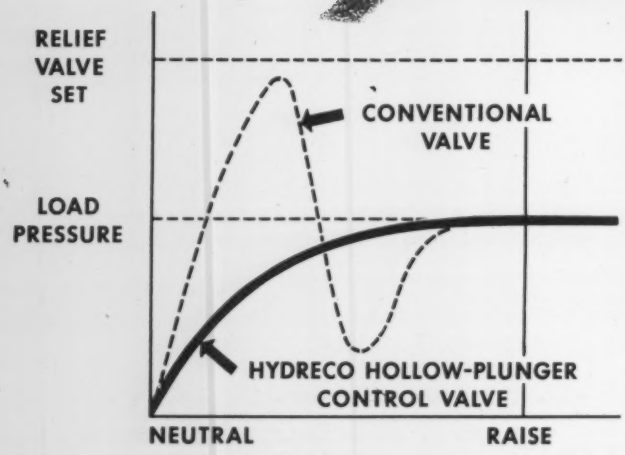


HOLLOW-PLUNGER* DESIGN

Check valves built-in to reduce mounting space. Staggered circular port openings for better throttling. Even pressure around plunger cuts out hydraulic locks. Plungers individually selected and hand fitted.

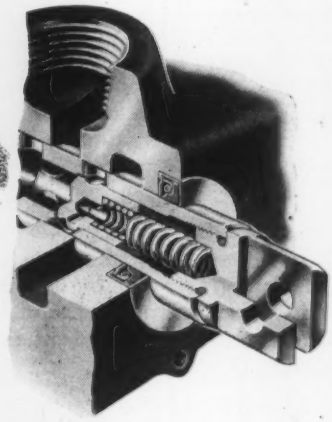
DIFFERENTIAL RELIEF VALVE

Cuts out relief valve noise and chatter. Light and low stressed springs used. Smoother operation, quicker opening and longer life. Four pressure ranges available with fine adjustment in each range.



OPERATION

Here is a graphic view of Hydreco's valve operation. There are no dead spots, no pressure peaks in Hydreco valves but a constant pressure rise from neutral to full open position. You get accurate throttling and smooth, quick action.



BUILT-IN CHECKS

Prevent any pressure drop in the cylinder while the pressure port is opening, as cylinder pressure is held while operating positions are changed. Momentary load drop is entirely eliminated.

Hollow-Plunger Design protected by existing U.S. and Foreign patents as well as patents applied for.

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HYDRECO
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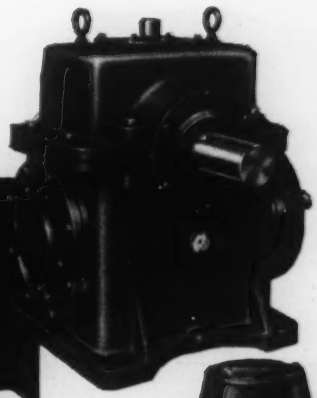
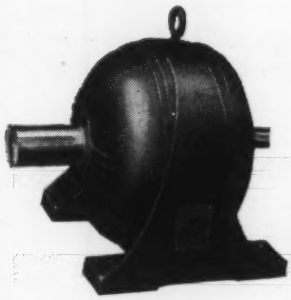
PUMPS · CYLINDERS · VALVES

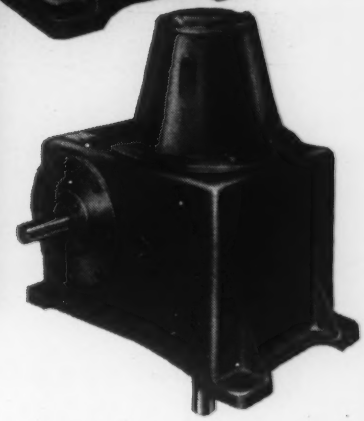
Foote Bros. Hypower Enclosed Worm Gear Drives assure economy in original cost and economy in operation. They bring a new compactness in design plus greatly increased thermal capacity. Available in vertical and horizontal types.





Foote Bros. Straight Line Enclosed Gear Drives will shortly be introduced. These compact units may be used with any standard motor. Ratios range from 5 to 240 to 1.

looking for drives?



Foote Bros. Hytop Enclosed Worm Gear Drives provide wider low-speed bearing span. Ideal for installation where low-speed shaft extensions cannot be supported by pilot or guide bearings at the end of shaft. Available in both Hygrade and Hypower types.

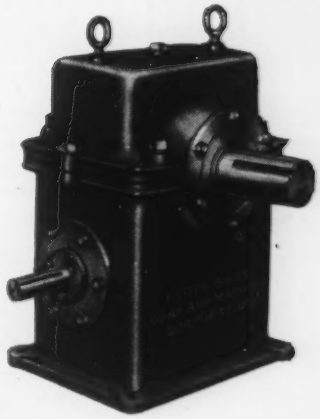
THEN LOOK TO FOOTE BROS.

If you require enclosed gear drives, the Foote Bros. line offers a wide variety of types, sizes and ratios to meet any need.

Nearly a century of engineering and manufacturing experience is back of Foote Bros. Drives. Two large plants contain the newest in gear generating equipment—new techniques in manufacture—better metallurgical control of materials—improved manufacturing methods—all assure you superior enclosed gear drives.

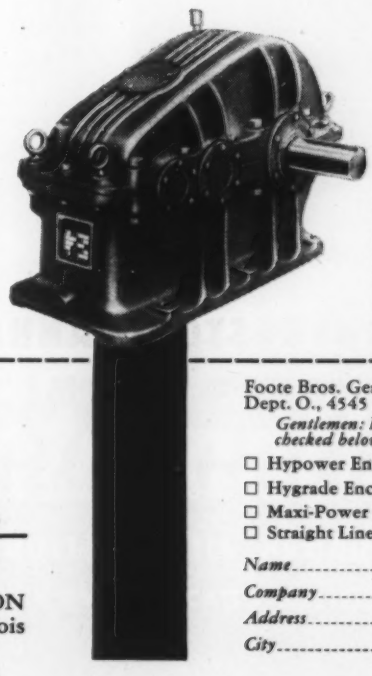
Mail the coupon for information.

Foote Bros. Hygrade Enclosed Worm Gear Drives have been newly engineered and now offer the maximum in rugged dependability. Specially designed for heavy-duty applications. Available in both horizontal and vertical types.



AVAILABLE FROM STOCK

A new policy of distribution now makes Foote Bros. Enclosed Worm Gear Drives available from stock. A range of sizes and ratios is offered to meet many industrial applications.



Foote Bros. Maxi-Power Helical Gear Drives are available in single, double and triple reductions. A newly engineered line that represents the last word in modern power transmission equipment.

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
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Foote Bros. Gear and Machine Corporation
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Gentlemen: Please send me information on drives checked below:

- ☐ Hypower Enclosed Worm Gear Drives
- ☐ Hygrade Enclosed Worm Gear Drives
- ☐ Maxi-Power Enclosed Helical Gear Drives
- ☐ Straight Line Enclosed Gear Drives

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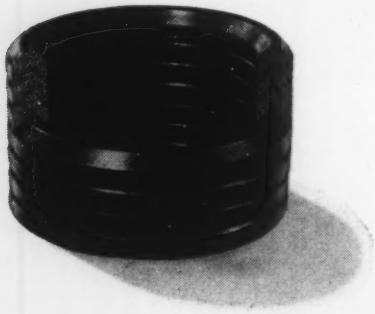
Specify

R/M VEE-FLEX PACKING RINGS

R/M Vee-Flex is the packing ring that automatically adjusts to give maximum sealing combined with minimum wear. The ring expands automatically under hydraulic pressure, contracts when pressure is released. Write for full details, dimensions, types of fluid to which adapted, variety of applications, and other facts.



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RAYBESTOS-MANHATTAN, INC., Manufacturers of Packings • Asbestos Textiles • Mechanical Rubber Products • Abrasive and Diamond Wheels • Rubber Covered Equipment • Brake Linings • Brake Blocks • Clutch Facings • Fan Belts • Radiator Hose • Powdered Metal Products • Bowling Balls

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Yes, we do coil-slitting, too—with mill-type machines that handle coils up to 60 inches wide by .150 thick.

Service to steel users is International's business... converting coils to flat, uniform, accurate-to-size sheets.

Here you can secure hot rolled, hot rolled pickled, cold rolled, galvanized, Terne plate, black plate, vitreous enameling, and electrical sheets.

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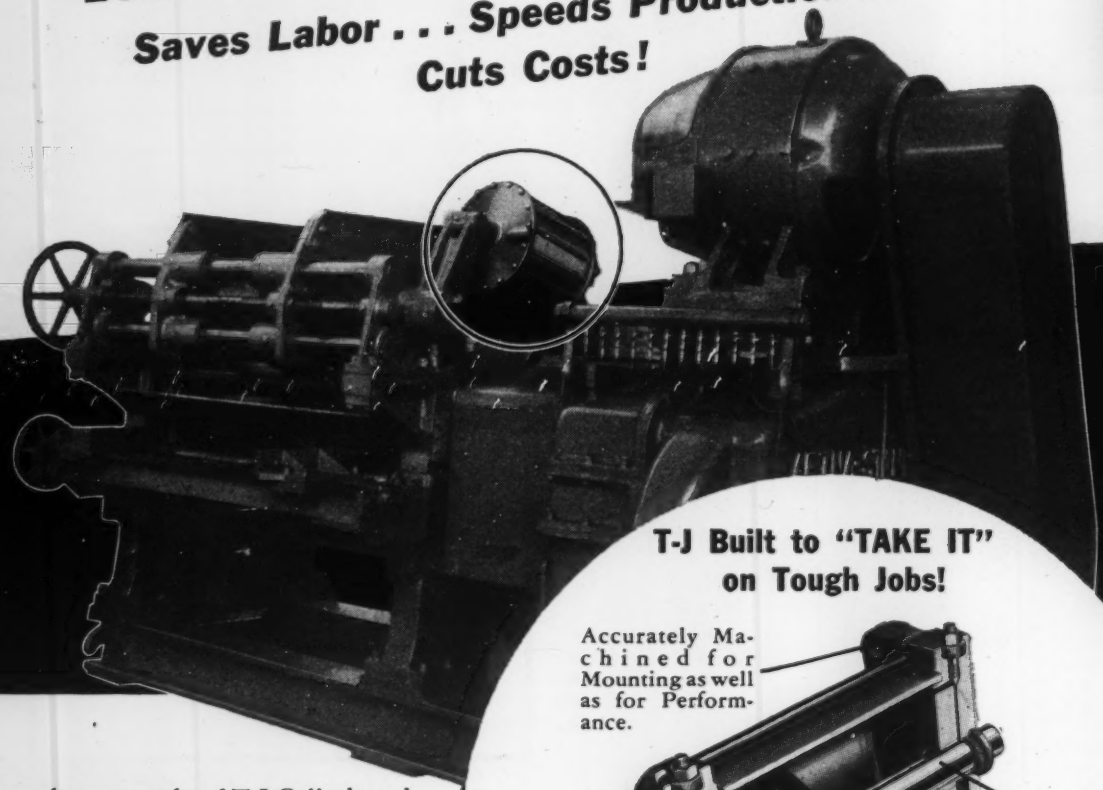

Here's another example of T-J Cylinders doing a job of power movement for industry . . . *efficiently . . . accurately . . . automatically.* This machine is an Aetna Standard Roll Type Coiler, which employs a T-J Air Cylinder to eject steel coils weighing up to 12,000 lbs.! As the strip of steel is completely coiled, kick-out fingers operated by the cylinder raise the coil and push it forward where it rolls on to conveyor.

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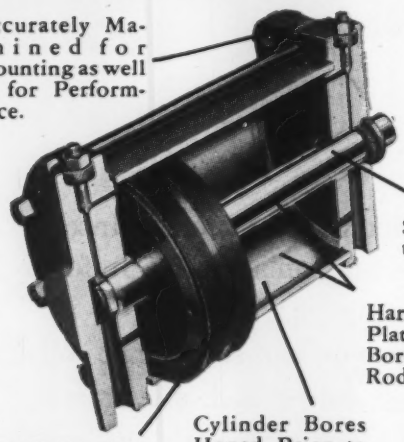
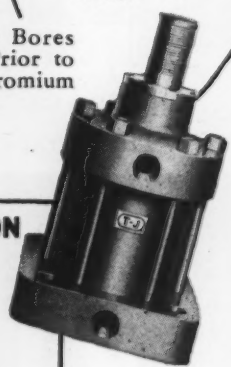
T-J Built to "TAKE IT" on Tough Jobs!





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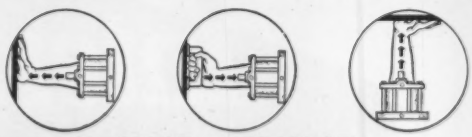

100 LB. or 50,000 LB.

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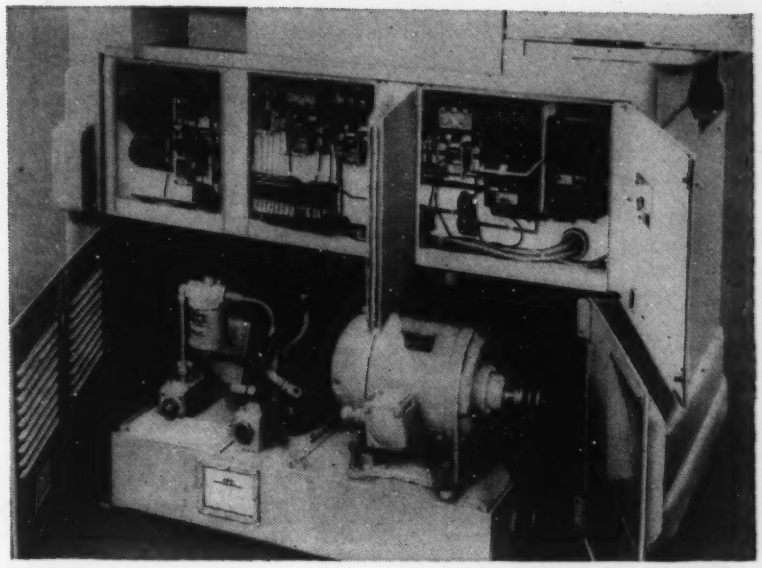
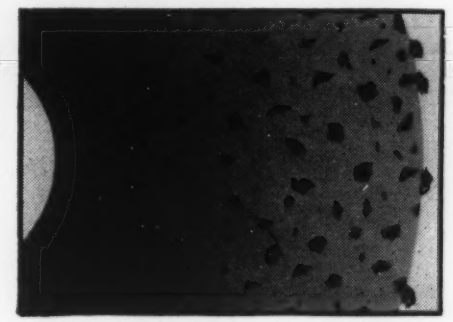
Protecting the Precision in Precision Machinery

The pumps, proper functioning of the control valves, and pistons in the hydraulic system controlling the automatic cycling and operation of this Heald Machine Company Centerless Grinder and other Heald precision machines, are protected by Cuno MICRO-KLEAN Filters to assure maintaining closest tolerances.



Guaranteed fluid conditioning . . . double cartridge life



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Cuno is the only manufacturer of replaceable-cartridge filters *guaranteeing* to remove all solids larger than specified, plus a large proportion down to 1 micron. MICRO-KLEAN's exclusive "graded-density-in-depth" permits smaller particles to penetrate to varying depths, eliminates surface loading, *doubles dirt holding capacity*. Resinous impregnation and polymerization prevents channeling, rupturing, shrinking and distortion.

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Cuno MICRO-KLEAN filters come in varying densities . . . capacities from a few to more than 800 gpm . . . connections from ⅜ in. IPS to 6 in. flanged . . . single or multiple cartridges to handle full flow. MICRO-KLEAN cartridges fit other makes; special lengths available for built-in installations.

● Your nearby Cuno engineering representative, handling the broadest line of fluid filters, is your best source of unbiased recommendations on fluid filtration . . . he offers you, before and *after* installation, service based on years of experience with engineering filtration systems.

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HELPFUL LITERATURE
FOR DESIGN EXECUTIVES

73. Flexible Shafting
Elliott Mfg. Co.—16-page illustrated Catalog No. 49 describes light, medium and heavy duty flexible shaft machines for wide range of operations. Details of various types of flexible shaft components are presented together with data on angle heads and handpieces.

74. Hydraulic Pumps
Borg-Warner Corp., Pesco Products Div.—4-page illustrated bulletin 123 discusses pressure loading principle of Pesco gear type hydraulic pumps and shows how this construction affords uniform rate of flow, high efficiency and compact design.

75. Welded Design
Lincoln Electric Co.—2-page illustrated machine design data sheet No. 102 explains how to design brackets for welded fabrication. This is one of series of guidance sheets which show fundamentals of design for components which utilize welding for their production.

76. Cold-Finished Steel
Jones & Laughlin Steel Corp.—16-page illustrated bulletin "You Can Make Them Better with Cold-Finished Jalcase" contains information on physical properties of this free-machining open hearth steel which is used extensively in production of machined parts where high mechanical properties and good response to heat treatment are required.

77. Hydraulic Drives
Rockwell Mfg. Co., Hydraulics Div.—4-page illustrated bulletin No. 101 describes Rockwell hydraulic drives which utilize Rotocycle pumps and motors. They provide variable speed flexibility in hydraulic power transmission. Typical applications involving constant speed, pressure and torque are shown.

78. Link V-Belts
Manheim Mfg. & Belting Co.—24-page illustrated booklet "Veelos—The Link V-Belt" describes applications and construction features, shows how to measure and install and gives full engineering data relative to this belting.

79. Speed Reducers
Farrel-Birmingham Co., Inc.—44-page illustrated bulletin No. 449 contains complete information on line of speed reducers in increased range of sizes and capacities. Contents include complete descriptions of single and double reduction type units, specifications, horsepower ratings, overhung load capacities, dimensions and weights.

80. Linear Motion Bearing
Thomson Industries, Inc.—12-page illustrated engineering catalog "Ball Bushings" describes ball bearings for linear motion and the ball recirculation principle of operation. Complete technical information as well as prices are given for various sizes of linear bearings.

81. Lubricating Devices
Gits Bros. Mfg. Co.—16-page illustrated "Price Guide Catalog" contains complete price information, discounts, specifications and numerical sequence along with identifying illustrations of the various lubricating devices available.

82. Pneumatic Devices
Bellows Co.—12-page illustrated bulletin CL-15 describes basic air motor which is composed of air cylinder, speed controls, four-way valve and necessary piping. Motors are available in four bore sizes from 1¼ to 4½ inches and in standard stroke lengths from 1 to 18 inches, with special strokes up to 60 inches being supplied on order. Also covered are air-powered feeds, vises, collet chucks, rotary feed tables and presses.

83. Flexible Couplings
Chain Belt Co., Baldwin-Duckworth Div.—8-page illustrated bulletin No. 48-6 describes line of roller chain flexible couplings and their various applications. Dimensions, prices, horsepower ratings and service factors are tabulated for convenience.

84. Strain Rate Pacer
Baldwin Locomotive Works—2-page illustrated bulletin No. 289 describes new strain rate pacer testing machine accessory designed to enable operators to maintain constant straining rates during loading of test specimens.

85. V-Belt Drives
United States Rubber Co.—100-page illustrated manual contains data to assist engineers in designing both multiple and light-duty V-belt drives. Included is comprehensive set of drive tables for multiple belts; complete sheave data covering construction, dimensions and weights; fractional horsepower drive layouts; and comparison tables with information on quarter-turn drives and hexagon double V-drives.

86. Selenium Rectifiers
Fansteel Metallurgical Corp.—20-page illustrated bulletin RDP-112 for engineers contains complete data on selenium rectifiers to aid in selection and proper use of selenium rectifiers. Cell sizes and ratings, characteristics, rectifier circuits and other application data are included.

87. Regulator
Westinghouse Electric Corp.—22-page illustrated bulletin describes functions and applications of Rototrol rotating regulator which has been applied to virtually every phase of steel producing from speed regulation of skip hoist drives to tension control for strip winding.

88. Centrifugal Castings
Ampco Metal, Inc.—Illustrated stock list card gives dimensions, chemical and physical characteristics and machining procedures for Ampco grade 18 centrifugal castings.

89. Test Cabinets
Bowser, Inc.—32-page illustrated catalog presents data on complete line of temperature, altitude and humidity simulating units. Included are altitude - pressure - temperature curves; thermal property tables for various materials; Fahrenheit table of relative humidity or percent of saturation and other research data.

90. Electric Air Control Valve
Hannifin Corp.—4-page illustrated bulletin No. 230 explains operating principle and applications of Directair electric air valve for control of single and double-acting air cylinders, air operated presses and similar equipment.

91. Small Control Motor
Alliance Mfg. Co.—1-page illustrated data sheet is descriptive of model RR split-phase resistor type reversible control motor which is available with or without reduction gears. Operating at frequency of 60 cycles on either 24 or 117 volts, this Powr-Pakt motor with 40:1 gear reduction will deliver 60 revolutions per minute.

92. Electrical Contacts
Gibson Electric Co.—6-page illustrated catalog No. C-12 describes electrical contact materials in which contact rivets are furnished, as well as standard sizes of flat, crowned and pointed types of contact rivets.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below.

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93. Diecastings

Parker White Metal Co.—4-page illustrated bulletin "Parker Die Castings" traces production of aluminum, brass and copper diecastings from blueprint stage to finished part. Typical die-cast components are shown.

94. Electric Air Valve

Hannifin Corp.—4-page illustrated bulletin No. 230 deals with Directair electric valve for control of single or double-acting air cylinders, air operated presses and similar equipment. Valve is solenoid controlled, pilot operated, reciprocating disk type which is airtight and self-lapping.

95. Electrogalvanized Sheets

Republic Steel Corp. — 16-page illustrated booklet form No. ADV-525 contains pertinent information on welding, soldering, cleaning, painting and fabrication of electro-zinc-plated sheets; points out economies obtainable with these products; and depicts numerous current applications.

96. Interval Timers

R. W. Cramer Co.—2-page illustrated bulletin No. 130 describes type IG interval timers for use when electrical equipment is to be turned on manually, run for preset time and stopped automatically. They can be supplied without external housings for built-in applications.

97. V-Belt Drives

Browning Mfg. Co.—76-page illustrated catalog No. V-136-E presents specifications on line of sheaves; stock, super, steel cable and double-V Gripbelts as well as Griproll and Griplink belts; engineering data on drives; and drive tables.

98. Carbon Brushes

United States Graphite Co.—40-page illustrated catalog B-49 contains complete data on carbon, carbon-graphite, electrographitic, pure graphite and metal-graphite motor and generator brushes and contacts for use on all types and sizes of rotating electrical equipment.

99. Ball Bearings

Dodge Mfg. Corp.—20-page illustrated bulletin No. A-120 on SC line of ball bearings gives pertinent enginering information covering pillow blocks, hanger bearings, flanged units, take-up units and cylindrical units as well as steel frame ball bearing take-ups.

100. Air Cylinders

Gerotor May Corp.—16-page illustrated two-color catalog section No. 53 describes line of air cylinders. Drawings are furnished for each model and size of cylinder showing complete detailed dimensions. Cylinder mountings described include rabbet, foot, trunnion, center line, blind end flange, rod end flange and clevis.

101. Hand Tachometers

Metron Instrument Co.—4-page illustrated bulletin No. 103 describes two different types of hand tachometers which are identical except for speed measuring ranges. Also listed are various adapters to extend applications of these instruments.

102. Electromagnetic Controls

Automatic Switch Co.—16-page illustrated catalog No. 700 describes service rendered to electrical industry relative to design of special electromagnetic controls for specific requirements. Listed are automatic transfer switches, remote control switches, contactors, relays and specialized controls.

103. Lock Nut

Security Locknut Corp.—4-page illustrated folder "Security, the Dependable Locknut" describes lock nut incorporating elliptical retainer ring which is pressed into round hole to produce powerful spring tension fit and permanenty combine parts into single unit.

104. Synchronous Motors

Electric Products Co.—4-page illustrated bulletin 211 shows design and construction features of synchronous motors rated from 10 to 1000 horsepower.

105. Fan-Cooled Speed Reducer

Cleveland Worm & Gear Co.—8-page illustrated bulletin "More Horsepower Per Dollar" cites case histories of installations of Speedaire fan-cooled worm gear speed reducers which show savings in space, weight and cost over conventional drives.

106. Rust Prevention

Parker Rust Proof Co.—24-page illustrated form No. A-2511 describes recent advances in rustproofing that result in improved economy and efficiency. Improvements include shorter processing time, lower operating temperature, improved chemicals, smoother coating and lower cost of application.

107. Hydraulic Control Valves

Hydraulic Equipment Co.—4-page illustrated bulletin V12-10948 is descriptive of Hydreco V12 series control valves having maximum capacity of 50 gallons per minute and recommended operating pressures up to 1400 pounds per square inch. Controls are available with from one to three plungers to control individually from one to three single or double acting hydraulic cylinders.

108. Bronze Parts

Johnson Bronze Co.—84-page illustrated catalog No. 490 contains complete dimensions, specifications and reference material concerning general-purpose, graphite, Ledaloyl self-oiling and electric motor bearings; oil grooving; solid and hexagon bronze bars; universal cored bars and other bearing materials.

109. Coil Springs

Illinois Coil Spring Co.—8-page illustrated booklet "Brief Guide for Spring Buyers" depicts compression, torsion and flat springs and wire forms which can be furnished in round, flat or square wire.

110. Dial Thermometers

Qualitrol Corp. — 4-page illustrated bulletin 100 explains features and uses of dial thermometers in several temperature ranges from—90°F to 1000°F. Indicators are available with dial diameters of 2-3/32, 3 and 5 inches. Stainless steem stems are standard at 2½ inches, but longer lengths can be supplied.

111. Welding Bosses

Ohio Nut & Bolt Co.—4-page illustrated bulletin 484 lists production sizes of round, square and flanged bosses for anchoring to sheet metal housings by projection welding. They provide bearings for shafts or push rods and can be tapped to provide adequate thread engagement.

112. Brake Motors

Star Electric Motor Co.—8-page illustrated bulletin No. B 501 presents technical data on construction and operation of integral brake motors which are individually designed for powering specific equipment.

113. Electrical Equipment

Comar Electric Co. — Illustrated looseleaf catalog presents information on relays, transformers, coils, terminals and other electrical equipment.

114. Plastic Materials

B. F. Goodrich Chemical Co.—4-page reference chart "Geon Polyvinyl Materials" lists various polyvinyl chloride materials such as resins, plastics and latices. Compounding methods, usable ingredients, processing techniques and finished parts are suggested.

115. V-Belt Drives

Dayton Rubber—12-page illustrated booklet "Power Transmitted Throughout Industry" describes line of V-belts incorporating rayon cords in load-pulling section to assure minimum stretch, maximum flexural strength and long life.

116. Drop Forgings

Drop Forging Association—60-page illustrated technical treatise "Metal Quality" contains reference data for designers and engineers on drop forgings. Development of metal quality progressively through hot-working operatings is explained. Steps involved in making forging dies, methods and equipment used in hot-working steel, and forging procedures for various types of parts are outlined.

117. Air & Hydraulic Cylinders

Hydro-Line Mfg. Co.—Two illustrated catalogs Nos. A-48 and H-48-LP deal with air cylinders and hydraulic cylinders for low pressure applications, respectively. Construction features are described, and complete dimensions are tabulated for various models and sizes to suit widespread industrial needs.

118. Hydraulic Controls

Sinclair-Collins Valve Co.—4-page illustrated bulletin "Sinclair-Collins Valves" describes cycle timer for plastics and rubber industires. Single and two-pressure; two, three and four-way; high and low pressure; hand operated air-steam-gas and hot or cold water valves are described.

119. Speed Reducers

Euclid Machine & Tool Co.—4-page illustrated bulletin "Euclid Universal Speed Reducers" shows available types, sizes and ratios of worm gear speed reducers. Single and double reduction reducers are described.

120. Flexible Couplings

Morse Chain Co.—24-page illustrated catalog "Morse Morflex Flexible Couplings" deals with line of couplings which are torsionally flexible; isolate vibration; cushion shock; compensate for misalignment; require no lubrication or maintenance and are impervious to water, dirt, oil and all weather conditions.

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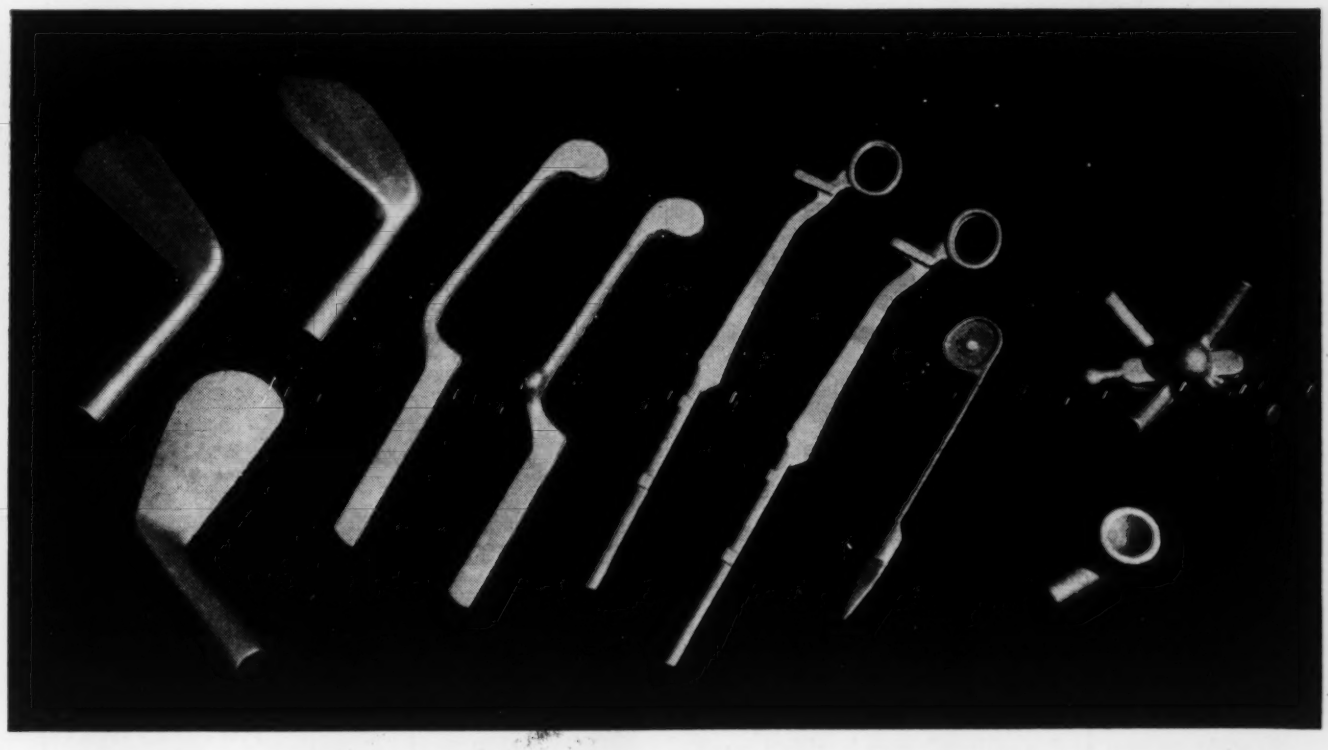

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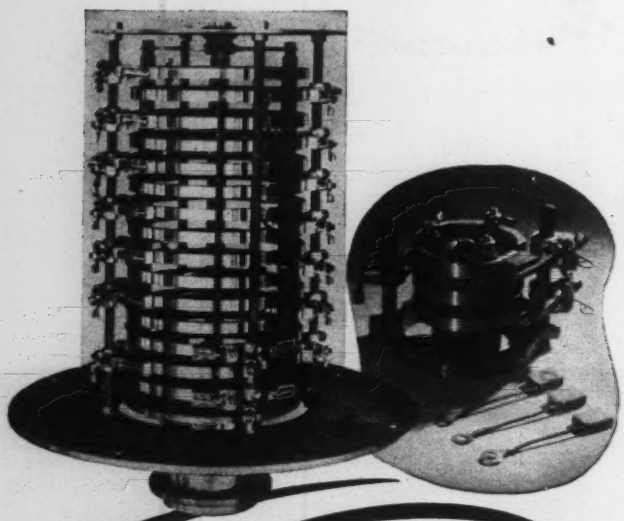

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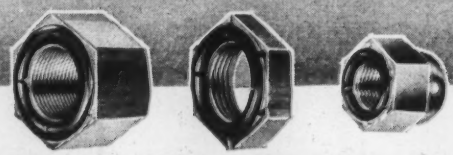

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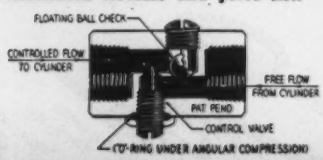

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ACADIA *Synthetic* PRODUCTS

DIVISION WESTERN FELT WORKS

Largest Independent Manufacturers and Cutters of Felt

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(above)
Grinder Pedestal.
(right)
Steel Carrying Case.

BOTH

Quality AND *Economy*

IN SHEET METAL FABRICATING

Here's how we *actually* do it: Your *finest* sheet metal units result from infinitely precise workmanship, using up-to-the-minute fabricating methods and equipment. *Costs* tumble with combined production efficiency and economy. When current procurement problems ease, call on us for service patterned exactly to your needs.

MANUFACTURERS
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MARSHALLTOWN DIAL THERMOMETERS

New
STAINLESS STEEL BULB AND NUT

THE COMPLETE LINE

Now furnished in stainless steel bulb and nut, Marshalltown dial thermometers are accurate, compact, durable instruments for the indication of liquid or gas temperatures. They are available in a variety of temperature ranges from minus 40° F. to plus 500° F. Actuation is positive, direct with full freedom — no gears or pinions. Available in sizes 2", 2½", 3½" and 4½".

WRITE TODAY FOR FULL DETAILS AND PRICES

Marshalltown Mfg. Co., Marshalltown, Iowa

SAVE THESE 8 WAYS WITH LAMINUM* SHIMS!

Simply p-e-e-l your adjustments! LAMINUM shims are precision gauge shim brass or steel built into a unit structure.

After peeling, the remaining shim is always uniform in gauge, with a hard surface...clean and smooth as glass.

1. Assembly time reduced up to 30%. No precision machining, grinding, filing, miking.
2. All adjustments made at the job by peeling laminations. No standby lathe.
3. No fumbling and counting loose, paper-thin wafers.
4. Less compressible than ordinary one-piece or stacked shims.
5. Cut to your exact specifications. Less than 1% rejects over the years.
6. Can be fitted with babbitted lugs to prevent oil and pressure loss.
7. No new skill required for use.
8. Your customer recognizes the plus value of less "down time" for maintenance and adjustment.

Send today for chart illustrating 46 money-saving, time-saving applications, detailed specifications, sample of LAMINUM.

*Laminum Shims (Reg. U. S. Pat. Off.) are solidly bonded laminations of .002 or .003 inch precision gauge brass or steel with a microscopic layer of metallic binder. Cut to your exact blueprint specifications.

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THE SOLID SHIM THAT peels FOR ADJUSTMENT

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1204 Union Street, Glenbrook, Conn.

SHIMS • SHIM STOCK • STAMPINGS • AN-COR-LOX NUTS

AIR CONTROL VALVES

"VALVAIRS"

Lever operated type illustrated

- NON-CORROSIVE
- NO METAL SEATS
- FULL PIPE AREA USED

60 types to choose from

2-WAY
3-WAY
4-WAY

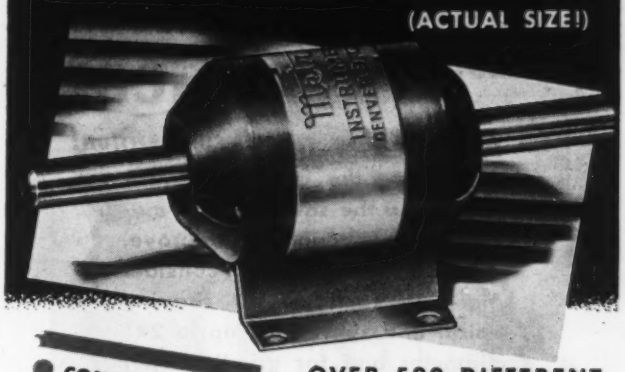
Ask for Bulletin "A-D"

VALVAIR CORPORATION • 454 Morgan Avenue, Akron 11, Ohio
AFFILIATE: SINCLAIR-COLLINS VALVE CO.

Rely Upon Valvair

Metron miniature SPEED CHANGERS

(ACTUAL SIZE!)



- COMPLETE
- STANDARDIZED
- ADAPTABLE
- PRECISION-BUILT FOR QUALITY PRODUCTS

BULLETIN NO. 100 Contains Details. Write for it!

OVER 500 DIFFERENT STANDARD RATIOS!

- Only 1.050" diameter; overall lengths from 3 3/16" to 4 13/16"!
- Ratios from 10:9 to 3,375:1 *standard!* Higher ratios available promptly.
- Transmit power *either way* up to 100:1 ratios!
- Concentric, ball-bearing input and output shafts; hardened steel spur gears; permanent lubrication.
- SPEEDS up to 20,000 RPM on output shaft.
- TORQUES to 2 lb.-in. on low speed shaft.

METRON INSTRUMENT COMPANY
442 Lincoln Street • Denver 9, Colorado

BUILT BY Metron MAKERS OF INSTRUMENTS FOR PRECISION MEASUREMENT

This fine tough forging makes a fine TOUGH TOOL

You can hoe, weed and cultivate with this excellent new combination garden tool made by Fraim Co., of Norfolk, Virginia.

Not only is it efficient, but it is very tough because National drop forgings are made with exceptional skill. The fibre-like grain structure of selected steel is reinforced at areas of impact and greatest wear.

Our fine drop forgings offer tremendous strength and maximum fatigue resistance.

Write us today for booklets describing our standard line of SAE yoke and rod ends, container handles and knife blades, etc.:—and send us your inquiries for custom drop forgings.

The Trademark "N" is your guarantee of Fine Quality Forgings.

THE NATIONAL LOCK WASHER CO.
DROP FORGING DIVISION
NEWARK 5 NEW JERSEY

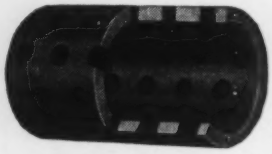
If it's a job for a *sleeve* bearing a Randall does it better

You're sure of longer, trouble-free service when you specify *Randall Bearings.*

They give you smoother, more dependable operation. *Built in* lubrication gives extra protection . . . plugs or grooves are machined into the bushing wall and filled with lubricating graphite to form part of the bearing surface.

Shafts run quieter, longer, almost frictionless in Randall Pillow Blocks, too. These self-aligning, self-lubricating pillow blocks have graphited or sintered bronze bushings in wool-felt-packed oil reservoir housings.

Cutaway shows a standard type, graphited bearing with plugs staggered to give complete lubricating coverage of the bearing surface. The Randall Line includes other types, including those for radial and thrust loads. Special graphited bearings can be produced to your specifications or we can graphite bearings for you.



Normal Duty Pillow Block

A general service pillow block with graphited, phosphor bronze bushing in an oil reservoir housing packed with SAE F-11 wool felt. One of six pillow block types in the complete Randall Line . . . for nominal to heavy duty on shaft sizes from ½" to 3-15/16", inclusive.

FREE—NEW . . .

Randall's Pillow Block Catalog 49, with complete data on new, low cost models, revised specifications and exclusive Randall design features . . . or ask for Bearing Catalog GB-43

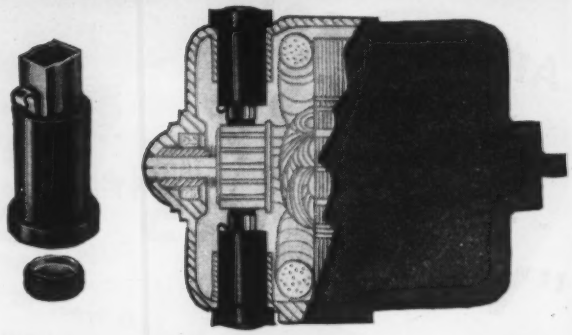
Randall Graphite Bearings, Inc.

609 W. Lake St., Dept. 417, Chicago 6, Ill.

PEMCO BRUSH-HOLDERS

FOR FRACTIONAL HORSEPOWER MOTORS

COMPLETE RANGE OF SIZES . . .



SAVES ASSEMBLY TIME AND LABOR!

Made in a complete range of standard and special sizes for fractional H.P. motors.

PEMCO Brush-Holders have been used for years by many of the country's leading motor manufacturers. They have proven themselves *in the field* under almost every condition.

Improve your operation, cut your costs, investigate PEMCO.

PHOENIX ELECTRIC MFG. CO.

711 W. LAKE ST. CHICAGO 6, ILL.

Sier-Bath

GROUND or SHAVED Gears

for products that outsell competition!

- Improve the quality of your gears and the sales of your machines are bound to improve. And for better gears, consider Sier-Bath facilities for shaving spiral and spur gears up to 24" diameter and for grinding spur gears to 16", spiral gears to 10" and splined shafts (both straight side and involute) up to 42" long. It will pay you to send your specs to Sier-Bath for quotation.

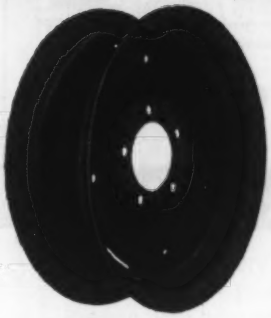
ALSO MFRS. OF SIER-BATH GEAREX & SCREW PUMPS

FOUNDED 1905 MEMBER A.G.M.A.

Sier-Bath GEAR and PUMP CO., Inc.

9263 HUDSON BOULEVARD NORTH BERGEN, NEW JERSEY

STOP! Don't throw those old AUTO TIRES away



A GREAT NEW IDEA Here's a 15" diameter IMPLEMENT WHEEL that takes discarded automobile tires — high pressure 5.50, 6.00 and 6.50. Dealers note. Farmers note.

and STANDARD 1⅜" SAE 1045 COLD ROLLED CENTERLESS GROUND SPINDLES

IMMEDIATE DELIVERY

FRENCH & HECHT
DIVISION
KELSEY-HAYES WHEEL COMPANY
DAVENPORT, IOWA
Wheel Builders Since 1888

LORD mountings regulate the regulator

The function of the Jack & Heintz Inverter is to convert the 27 volt DC output of the airplane's power supply to 115 volt, 400 cycle AC power required for various applications, including radar. Voltage control within close limits is essential. The electronic voltage regulator contains small vacuum tubes and these must be isolated from airplane vibration and shock due to rough landings and other causes.

A Lord Vibration Control System solved the problem of vibration interference. The regulator is supported by two Multiplane Mountings and one Sandwich Mounting which effectively isolate and protect it from outside interference.

Whether your product needs protection from outside interference for its best performance, or needs effective control of its own vibratory forces, Lord engineers can help you.

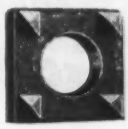
See our bulletin in Sweet's 1949 File for Product Designers or write for Bulletin 900. It describes the complete line of Lord products and services.

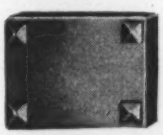
LORD MANUFACTURING COMPANY, ERIE, PA.
Canadian Representative: Railway & Power Engineering Corp. Ltd.

LORD Vibration Control Systems

Use Ohio Fasteners and Fittings for Projection Welding to reduce costs and improve your products.

Weld Bosses





Weld Pads

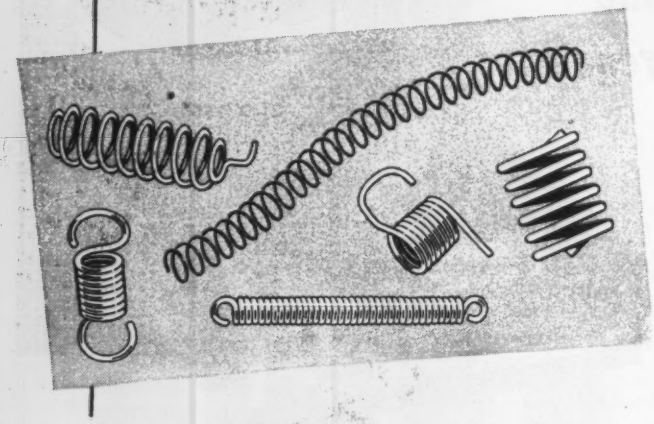
The projections on Ohio fasteners and fittings cannot collapse, thereby developing the greatest possible resistance to electric current flow. The proper heat is generated to fuse the projection into the sheet metal without spatter or discoloration.

Send for samples and bulletins

THE OHIO NUT & BOLT COMPANY
620 N. Front St., Berea, O.

NOW'S THE TIME...

GET A SPRING CHECK-UP ON COSTS



With buyers more cost-conscious, it's time to double-check your products price-wise. What about the springs you are now using, or planning to use? Are you *sure* they are the most *practical* and *economical* springs for the jobs required?

Lewis Spring engineers have saved manufacturers many hundreds of dollars by working carefully with design engineers in specifying more economical, but equally effective springs, for their products. Fancy "extras" don't contribute to product appearance or efficiency in most cases.

You can rely on Lewis Engineers' recommendations because they are underwritten by years of experience in the design, production and application of all types of springs for all types of products.

Get a spring check-up now. There's no obligation.

LEWIS SPRING & MFG. CO.
2636 North Ave., Chicago 47, Ill.

Lewis PRECISION SPRINGS

THE FINEST LIGHT SPRINGS AND WIREFORMS OF EVERY TYPE AND MATERIAL

A RUGGED PAIR!

Correctly Applied ...that's the

VIKING ROTARY PUMP

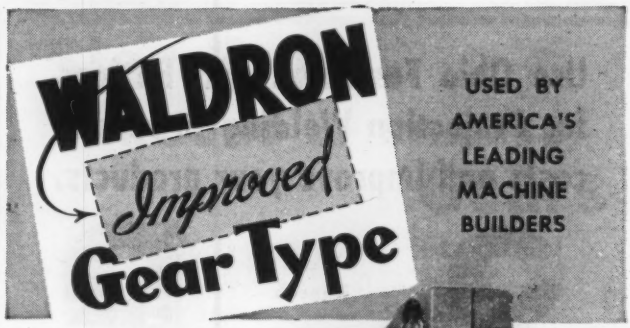
The sturdiness built into the Viking rotary pump is well illustrated in the Viking rotor and idler above. Their wide tooth form and slow operating speed result in efficient operation, with long, dependable service.

This original "gear within a gear" design, most copied of all rotary pump principles, is the key to good pumping. Look to Viking for the correctly engineered pump for your job.

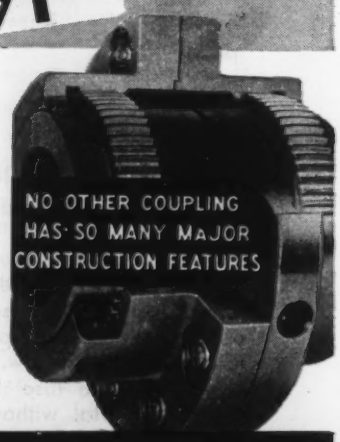
Send us your pumping problem today and ask for bulletin 49SH. Both problem and request will be given immediate attention without obligation to you.

See Our Catalog in SWEETS

Viking PUMP COMPANY
Cedar Falls, Iowa

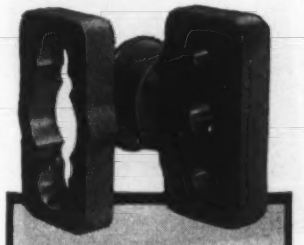


Users recognize the WALDRON Coupling as the most advanced design of the Gear Type. Compare it with ordinary types from a standpoint of shaft size, horsepower, speed and service. For design and construction details, ratings, service factors, etc.—write for descriptive catalog.



JOHN WALDRON CORP.
Main Office and Works
New Brunswick, New Jersey
COUPLINGS

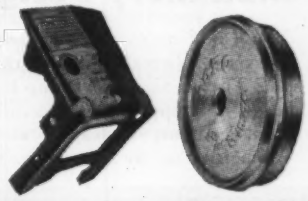
ALUMINUM DIE CASTINGS
by
Char-Lynn



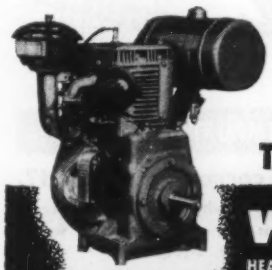
A Special Char-Lynn process die-casts these heavy-section castings **WITHOUT POROSITY!**

Even complex shapes can be economically produced by Char-Lynn methods. Careful handling reduces the number of operations in machining and assembling. Production retains exact shapes and dimensions and is delivered with good surface finishes . . . *Capacity up to six pounds.*

Write or phone for engineering consultation and estimates



Char-Lynn Company
2873 26th Avenue South • DUpont 2354
Minneapolis 6, Minnesota



20% MORE H.P.
15% LESS WEIGHT
10% LOWER COST
That's the *new* MODEL AEN

WISCONSIN HEAVY-DUTY *Air-Cooled* **ENGINE!**

Replacing the universally popular Wisconsin Model AEH Air-Cooled Engine, the new Model AEN turns up 7.5 H.P. at 3,000 R.P.M. as against 6.1 H.P. at 3,200 R.P.M. delivered by the engine it replaces. Weight: 110 lbs., as against 130 lbs. for the AEH. Price: approximately 10% lower.

All this has been accomplished without sacrificing heavy-duty crankshaft capacity or any of the traditional Wisconsin features such as: Tapered roller bearings at *both* ends of the drop-forged crankshaft; oil pump and spray lubrication; weather-sealed high tension outside magneto with impulse coupling for quick starting and dependable ignition in any climate, in any weather; flywheel-fan air-cooling — extremely efficient at all temperatures from sub-zero to 140°F.

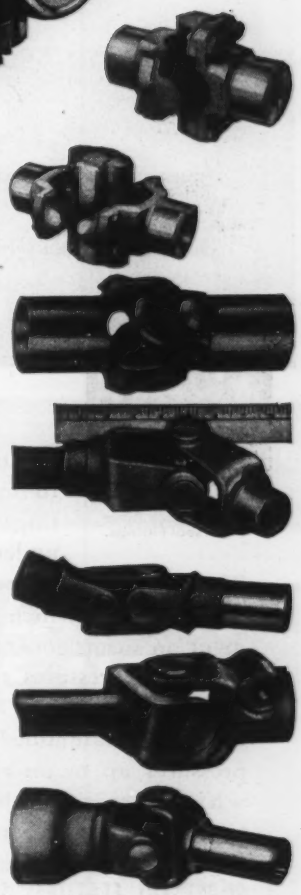
The Model AEN represents a major achievement in the design and construction of a light weight heavy-duty power unit for all-purpose power applications. Write for Bulletin S-109.

The Wisconsin line includes 4-cycle single cylinder, 2- and 4-cylinder models in a complete power range from 2 to 30 H.P.

MOST H.P. HOURS

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines

MECHANICS makes the most complete line of SIZES and TYPES of Roller Bearing UNIVERSAL JOINTS — for every application. Sizes range from 200 to 50,000 foot pounds torque, with a wide variety of end connections and shaft arrangements. Millions of cars, trucks, busses, tractors, farm, construction and industrial machines, and aircraft of all types benefit from design and manufacturing advantages of MECHANICS (Lifetime or Once-a-Season Lubricated) Roller Bearing UNIVERSAL JOINTS. In addition to conventional applications, we make joints for steering columns, etc. Our new catalog — showing the complete line of MECHANICS Roller Bearing UNIVERSAL JOINTS will be sent to manufacturers, upon request.



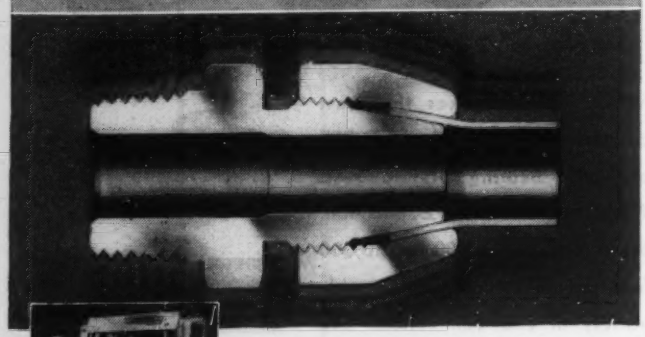
MECHANICS UNIVERSAL JOINT DIVISION
Borg-Warner BW
2032 Harrison Avenue
Rockford, Illinois

MECHANICS
Roller Bearing
UNIVERSAL JOINTS
For Cars · Trucks · Busses and Industrial Equipment

Vibration under high pressure?

Superseal

Flared Tube Fittings make light wall tubing practical



Jaeger Mfg. Co. compressors have Superseal Fittings.

Would you switch to light wall tubing if you could obtain fittings that withstand vibration under high pressure?

Then you'll be interested in Superseal Flared Tube Fittings which are now standard equipment on steam generators and on air compressors with pressures running up to 600 P.S.I. The same fittings in an Underwriters' Laboratories test maintained a leakproof joint under pressures up to an amazing 8090 pounds, at which pressure the steel tubing split. Grinnell Company, Inc., Providence 1, R. I.

SUPERSEAL FEATURES SAVE TIME, SAVE MONEY!

PERMANENTLY LEAKPROOF JOINTS unaffected by vibration.

FOR ANY TUBING, including welded steel tubing, using a single flare.

LONG, SMOOTH, TAPERED 10° FLARE on fitting and inside of self-aligning nut hold tubing securely.

NO SHEARING ACTION to injure tubing at point of flare when nut is tightened. Tubing actually reinforced.

REPEATED DISCONNECTIONS without injury to tubing.

PRODUCTION FLARING up to 2000 a day on inexpensive flaring machine.

STOCKED IN BRASS AND STEEL, ⅛" to ½".

99 YEARS PIPING

GRINNELL

how to save space, material and money

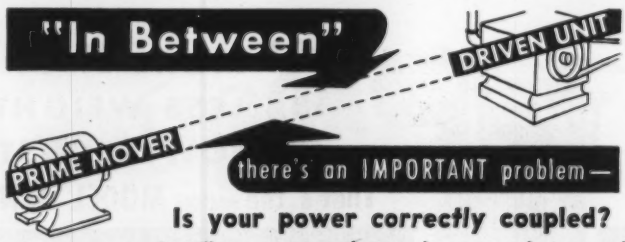
By Using

TUTHILL

Stripped Pumps In Your Machinery Designs

You'll find many practical suggestions for incorporating the pump directly into the design of your equipment in this Tuthill Stripped Pump bulletin. It presents the two types of stripped pumps available, designed for lubrication, coolant, hydraulic and liquid transfer service. Capacities up to 200 g.p.m. Send for your copy today.

TUTHILL PUMP COMPANY
939 East 95th Street . Chicago 19, Illinois . Phone RE 4-7420



Is your power correctly coupled?

It will pay you to know why you make sure of protection against power lag and loss, and wasted maintenance time when you equip with

LOVEJOY L-R FLEXIBLE COUPLINGS

Every Lovejoy L-R fitted to its particular job.

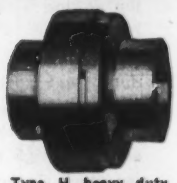
DESIGN AND CONSTRUCTION the simplest. Free-floating resilient load cushions suspended between rugged metal jaws, instantly adjust to every emergency.

CUSHION MATERIALS: Metalflex, for heavy shock loads; Leather for sustained loads, greater misalignment; multiflex rubber-duck for fluctuating loads; "SX" (armored rubber), applicable to any speed, any load fluctuation.

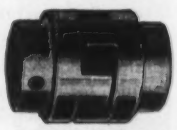
NON-LUBRICATED. NO TEARDOWNS FOR CHANGING CUSHIONS. DELIVERIES FROM STOCK.

Send for Catalog and Selector Charts. Complete line, 1/6 to 2500 h.p.

Ask for New Lovejoy Bulletin on specially designed couplings to latest AISE standards for D-C mill motors.



Type H heavy duty Pat. & Pats. Pend.

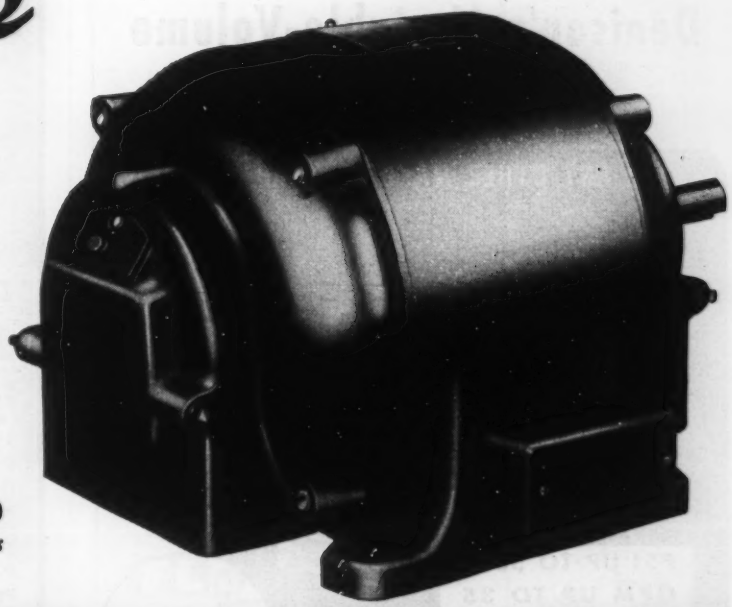


Type A 1/6 to 50 h.p. Pat. & Pats. Pend.

Also Mfrs. Lovejoy Variable Speed Controls, and Dix Universal Joints.

LOVEJOY FLEXIBLE COUPLING CO.
5018 W. Lake Street **Chicago 44, Illinois**

HERE'S MOTOR EXPERIENCE THAT CAN BE *yours*



● A high percentage of all Peerless Motors are manufactured to meet the specific operating requirements of the equipment with which they are to be used. Answering these motor problems has given Peerless engineers an experience that can be yours when you call Peerless for advice on motor applications.

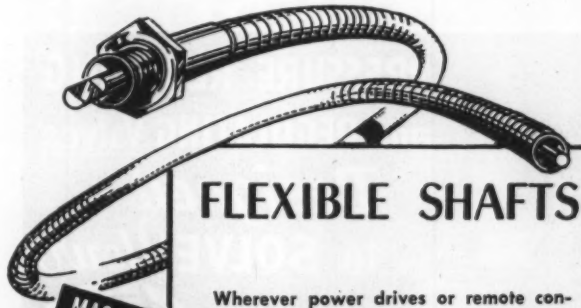
You will save time, energy and money by turning your motor problems over to Peerless. Call on us by telegram or telephone. Increased engineering and production facilities can be put to work for you promptly.

THE PEERLESS ELECTRIC COMPANY • WARREN, OHIO

Manufacturers of Quality Motors for more than 55 years

Single Phase • Polyphase • Direct Current Motors

ALL *Peerless Motors* ARE "PEERLESS REGISTERED"



FLEXIBLE SHAFTS

MACHINERY

ELECTRONICS

AUTOMOTIVE

AIRCRAFT

CIRCLE

Wherever power drives or remote control are required, you can depend upon us to produce the Flexible Shafts that will meet the exact specifications. We have years of experience in manufacturing flexible shafting for all types of industry. If we do not have what you require in stock, we can make shafts to your specifications. Our engineers will be glad to work out your problems without obligation.

Many new uses for flexible shafts that carry power around any corner have been developed by our engineers. . . in machine shops, electronic, automotive, aircraft, in all industries where power drives or remote control are required.

Write for Manual X.

F. W. STEWART MFG. CORPORATION

4311-13 RAVENSWOOD AVE. CHICAGO 13, ILL.

WEST COAST BRANCH: 431 Venice Blvd.; Los Angeles 15, Cal.

Now it's EASY to MEASURE NOISE

It's Just as Easy as This!

Little larger than a flashlight and just as portable — simply point the Scott 410-A Sound Level Meter at the noise source and read the meter. An amazing advance in SLM design—entirely self-contained, no separate power source or microphone, unhampered by interconnecting cables, its accuracy fulfills ASA standards. Provision for remote mike, vibration pickup, etc. . . And Scott quality construction thru-out.

FEATURES

Range, 34-140 db. above ASA reference level. Humidity sealed crystal, diaphragm mike. Two-speed type meter. Simple recalibration. 11⅝ x 2½" diam.; weight 2 lbs., 7 oz.

Net Price $249.00

Order direct from our Instrument Division.

HERMON HOSMER SCOTT INC.

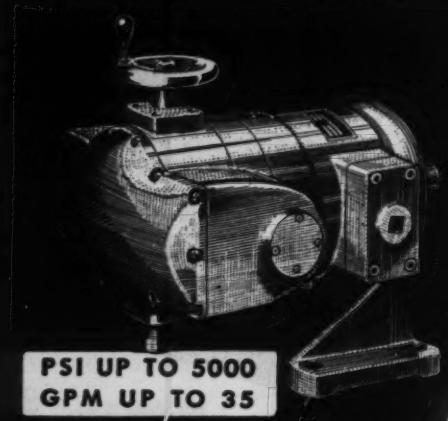
"PACKAGED ENGINEERING"

385 PUTNAM AVE. • CAMBRIDGE 39, MASS.

Just Compare

Denison's Variable-Volume HydrOILic Pumps

WITH ANY OTHER MAKE OF PUMP



PSI UP TO 5000
GPM UP TO 35

COMPARE COST of these Denison Pumps with *any other* variable-volume pumps—even with pumps rated at only *one-half* their capacity. You'll quickly see the advantages of using Denison's 5000 psi pumps, even on your 2500 psi requirements. For little or no extra cost you get the extra efficiency and longer wear of a pump operating at only *one-half* its capacity. And you have reserve capacity if needed. Wherever you need 5000 psi *or less*, you're ahead with a Denison hydraulic pump!

COMPARE CAPACITIES! Denison pumps give you up to full 35 gpm capacity in rugged, compact form. Full pressure range from 0 to 5000 psi available with either hand-wheel, stem or pressure-compensating controls.

COMPARE QUIETNESS! Quietness of operation is another outstanding feature of these Denison pumps. They reduce noise to a negligible factor!

COMPARE SIZE! The compactness of Denison pumps—makes them easier to adapt to your specific needs. Size for size, they have no equal. Write today for Bulletin P-2.

CHOICE OF CONTROLS

HANDWHEEL CONTROL, for quick, easy manual control of pump delivery.

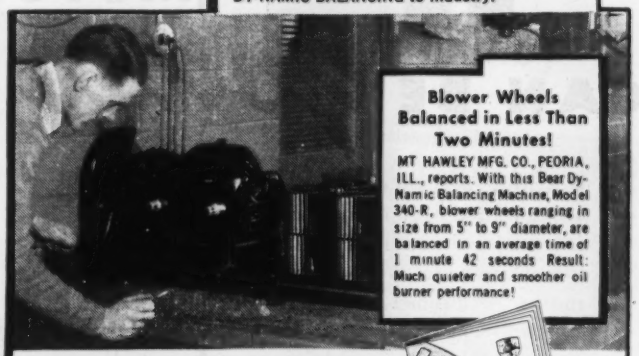
STEM CONTROL for use with mechanical control of pump volume.

PRESSURE—COMPENSATING CONTROL, for fully automatic control of pressure and volume.

THE DENISON ENGINEERING COMPANY
1156 Dublin Road • Columbus 16, Ohio

DENISON EQUIPMENT for APPLIED HydrOILics

CASE REPORT No. 52 from a series of actual cases recording the successful application of BEAR DY-NAMIC BALANCING to Industry.



Blower Wheels Balanced in Less Than Two Minutes!

MT HAWLEY MFG. CO., PEORIA, ILL., reports. With this Bear Dy-Namic Balancing Machine, Model 340-R, blower wheels ranging in size from 5" to 9" diameter, are balanced in an average time of 1 minute 42 seconds. Result: Much quieter and smoother oil burner performance!

Dy-Namic Balance FASTER!

FREE MANUAL tells how...

You can obtain improved product performance and elimination of noise and vibration at lower cost through this *faster* Bear Dy-Namic Balancing Method. Lower initial capital investment and a low cost-per-unit are made possible by this revolutionary Bear Method. With Bear, Dy-Namic Balancing is speeded up to a point where the operation hardly interrupts routine production . . . simplified to a point where men and women learn to Dy-Namically Balance rotating parts in just a few hours.

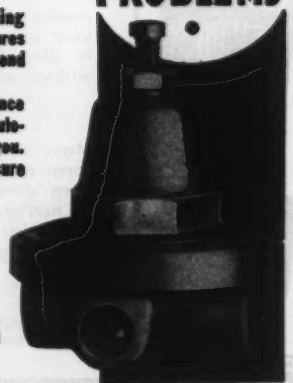
Send now for this FREE fact-packed 22-page Dy-Namic Balancing Manual for rotating parts weighing from 4 oz. to 8 tons! Write: Bear Mfg. Co., Dept. M-4, Rock Island, Illinois.

BEAR STATIC AND DY-NAMIC BALANCING MACHINES

2967

PRESSURE REDUCING and REGULATING Valves *Designed* to SOLVE *Your* Pressure PROBLEMS

If you manufacture equipment using water, air, steam or gas pressures which need to be controlled, send your problems to us.
Our twenty-five years of experience in the manufacture of special automatic valves is available to help you. Send us the details of your pressure problems.

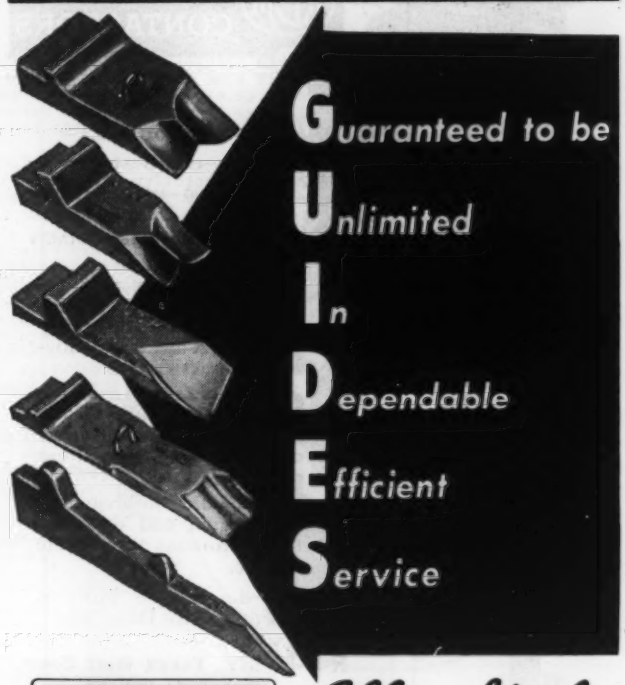


Write for your free copy of our new 1948 Catalog for complete details on standard CASH-ACME Products.

CASH-ACME *Automatic Valves*

A.W. CASH VALVE MANUFACTURING CORPORATION
6613 EAST WABASH AVENUE DECATUR, ILLINOIS, U. S. A.

ROLLING MILL GUIDES



Guaranteed to be
Unlimited
In
Dependable
Efficient
Service

CALUMETAL Alloy Steel

CALUMET STEEL CASTINGS CORP.
1636 SUMMER ST. • HAMMOND, IND.

Remote Controls... a Problem?

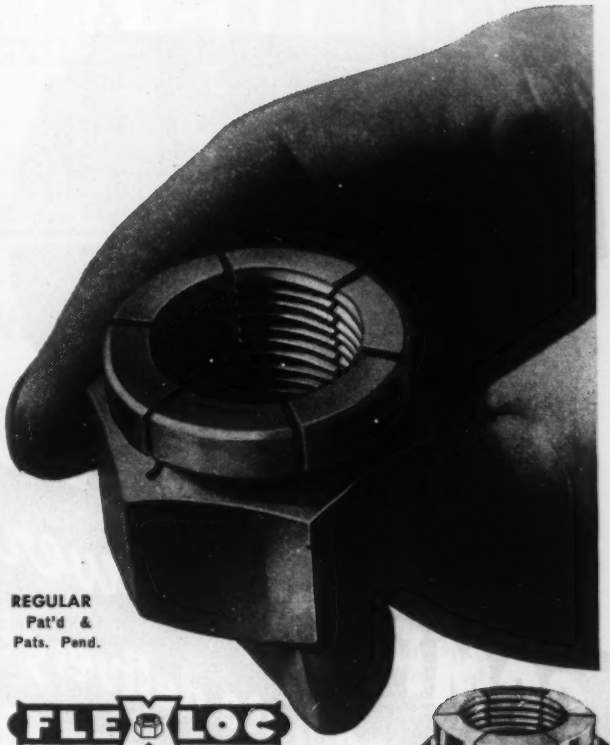
Take advantage of our free engineering service!

In our thirty years of manufacturing remote controls, we've met and solved many unusual problems. Installations have varied from complicated pattern-setting controls for textile machines to simple push-pull controls for power lawn mowers. In a substantial number of cases, a thorough understanding of the problem resulted in an improved control installation at a lower cost. Perhaps your product offers a remote control problem that we can tackle.

Why not let our design and engineering experts go to work on your control requirements? We would be pleased to offer you the benefit of our experience without obligation. Just write us for details.

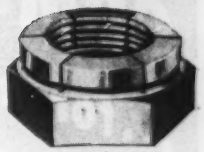
Flexible and rigid remote controls
Arens controls are noted for their long, trouble-free operation even under the most difficult operating conditions. They are low cost, easy to install, smooth working, and require virtually no maintenance. Whatever your remote control requirements are, considering Arens first will often save you money.

ARENS CONTROLS, INC.
2257 S. Halsted St., Chicago 8, Ill.



REGULAR
Pat'd &
Pats. Pend.

FLEXLOC



THIN

ONE-PIECE SELF-LOCKING NUTS

. . . WON'T SHAKE LOOSE ...REDUCE MAINTENANCE

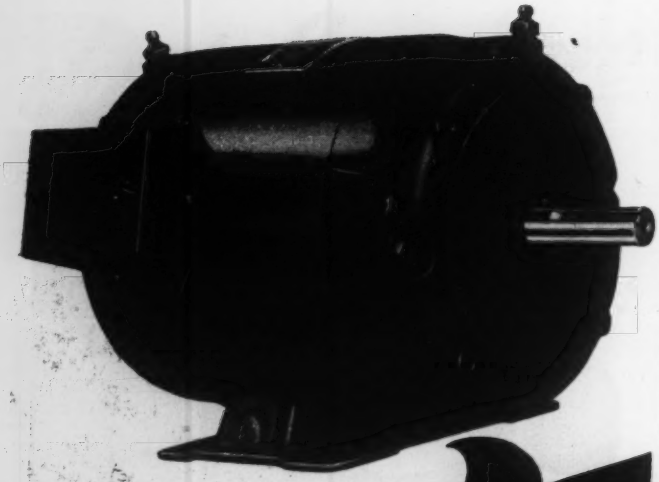
Invariably, when nuts loosen, they cause shutdowns, loss of production, and bad tempers all around. All this can readily be eliminated by installing the one-piece, self-locking "FLEXLOC", because *it positively will not shake loose* and positively cuts cost of maintenance.

The all-metal, one-piece resilient "FLEXLOC" is becoming increasingly popular, because it is processed to have an exceptionally uniform torque and, because it packs a stop, lock and plain nut all in one. "FLEXLOC" accommodates itself to a wide range of thread tolerances and can be used over and over again without losing much of its torque. And, being a stop nut, it stays locked in any position on a threaded member. It is not affected by temperatures commonly met.

Available in "thin" and "regular" types—in sizes from #6 to 2" in diameter—in NC and NF thread series. Write for your copy of the "FLEXLOC" Catalog.

OVER 46 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.
JENKINTOWN, PENNSYLVANIA, BOX 102
CHICAGO • DETROIT • ST. LOUIS • SAN FRANCISCO



COMPACT Power ...for immediate delivery!

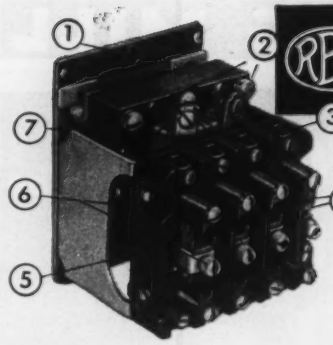
This small, sturdy, fractional H.P. motor (Type C) is now available for immediate delivery and can be readily adapted to a wide range of industrial uses. Measuring only 7" high, it is ideal for jobs where space is limited.

Excellent for continuous, general purpose duty on pumps, fans and hoists. It's tops in versatility—high torque, rated 1/4 to 1 H.P. in 12 different ratings, 50 & 60 cycle. Sealed ball bearings require but infrequent lubrication and dustproof housing assures long life even under rigorous operating conditions. Furnished in 2 or 3 phase only. Small, powerful, compact, this high quality Cleveland Electric Motor will give you many hours of dependable service.

You'll be interested in our prices and ability to deliver fast. Write now for complete information on our entire line of general and special purpose motors.

SPECIAL MOTORS FOR SPECIAL PURPOSES

CLEVELAND ELECTRIC MOTOR CO.
5213 CHESTER AVE. • CLEVELAND 3, OHIO



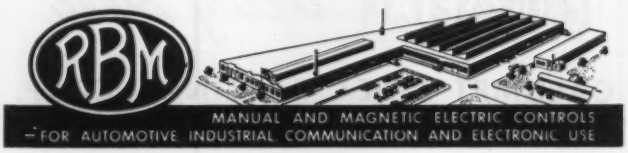
RBM INDUSTRIAL CONTACTORS

2 TO 8 POLE
600 VOLT A. C.
10—15 AMPERE SIZES
REVERSING—NON-REVERSING TYPES
INTERCHANGEABLE CONTACTS

1. Heavy steel base.
2. Coil readily replaced by removing 2 heavy screws holding E-shaped magnet frame.
3. Accessible solderless type terminals are conveniently located. All line terminals at top; load terminals at bottom.
4. Any pole can be changed from normally open to normally closed, or vice-versa, without additional parts.
5. Melamine stationary contact block and movable contact carrier.
6. Stationary and movable contacts can be readily replaced with use of screw driver only and without removing wiring.
7. Vacuum impregnated magnet coil designed for continuous 50/60 cycle service.

For descriptive bulletin No. 600 write Dept. H-4

R-B-M DIV., ESSEX WIRE CORP.
LOGANSPORT, INDIANA



MANUAL AND MAGNETIC ELECTRIC CONTROLS
—FOR AUTOMOTIVE INDUSTRIAL COMMUNICATION AND ELECTRONIC USE

When SPACE Counts...

"SEALOL"

"Sealol" packs full sealing effectiveness into an extremely small space. Compact design, plus the ability to handle high shaft speeds, high pressures, and high temperatures makes "Sealol" the perfect answer to difficult sealing problems. The Balanced Pressure feature keeps frictional heating and loss of power to a minimum.

Consult our engineering department on design problems. Bulletin No. 5 will be sent upon request.

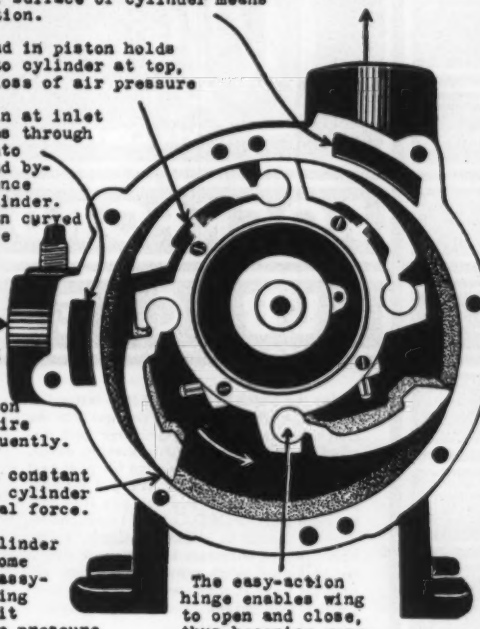
SEALOL CORPORATION
45 WILLARD AVENUE • PROVIDENCE 5, R. I.
Chicago · Cleveland · Detroit · Los Angeles · New York · St. Louis · San Francisco

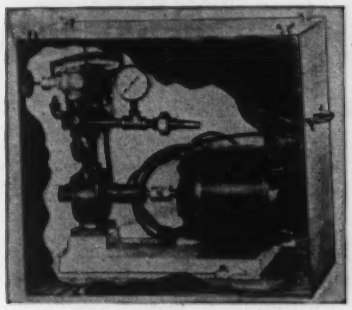
LEIMAN BROS.
ROTARY
POSITIVE

VACUUM PUMPS

AIR MOTORS
GAS BOOSTERS
PRESSURE BLOWERS

with the
CURVED WINGS
that
TAKE UP
THEIR
OWN WEAR





A PORTABLE UNIT

On Automatic Machines of Many Styles and Functions including Paper Feeding, Dehydrating, Pump Priming, Gas Boosting, Liquid Agitation, etc.

OPERATORS OF Feeding Machines and Devices Handling Sheets of Paper or Other Materials Prefer These Vacuum Pumps Because of Their Trouble-Proof Operation!

LEIMAN BROS., INC.

162-1 CHRISTIE STREET, NEWARK 5, N. J.

Acme Offers
Complete Facilities for

PRECISION GRINDING

FAST SERVICE... LOW COST

- INTERNAL
- EXTERNAL
- CRUSH FORM
- CENTERLESS
- TWIN DISC
- SURFACE
- THREAD

Acme is equipped to handle all types of precision grinding. Expert craftsmen, using newest methods and modern equipment, will do the job for you faster, better, more economically. Acme also offers a flat lapping service that can finish surfaces to within millionths. Write for details.

Acme Industrial Company

Makers of Standardized Jig & Fixture Bushings

211 N. LAFLIN STREET • CHICAGO 7, ILLINOIS

THE SERVICE SHOP TO INDUSTRY FOR MORE THAN 25 YEARS

NO TEA CUP

There is enough bronze being poured here for a hundred centrifugal castings—or maybe not enough for one!

We offer centrifugal castings from 2" length by 3" O. D. all the way up to 328" length by 54" O. D. (world's largest). We make your size.

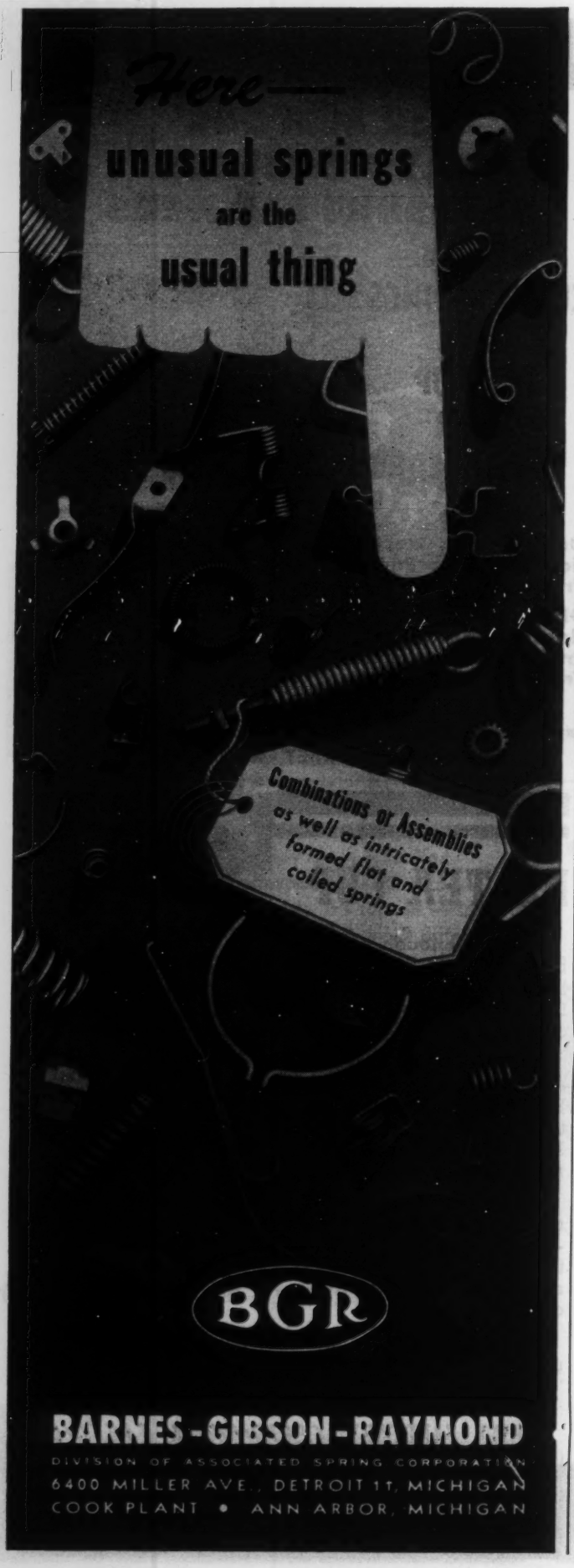
All our castings—from the pigmies to the giants—have these characteristics in common . . . density, uniformity, and freedom from porosity.

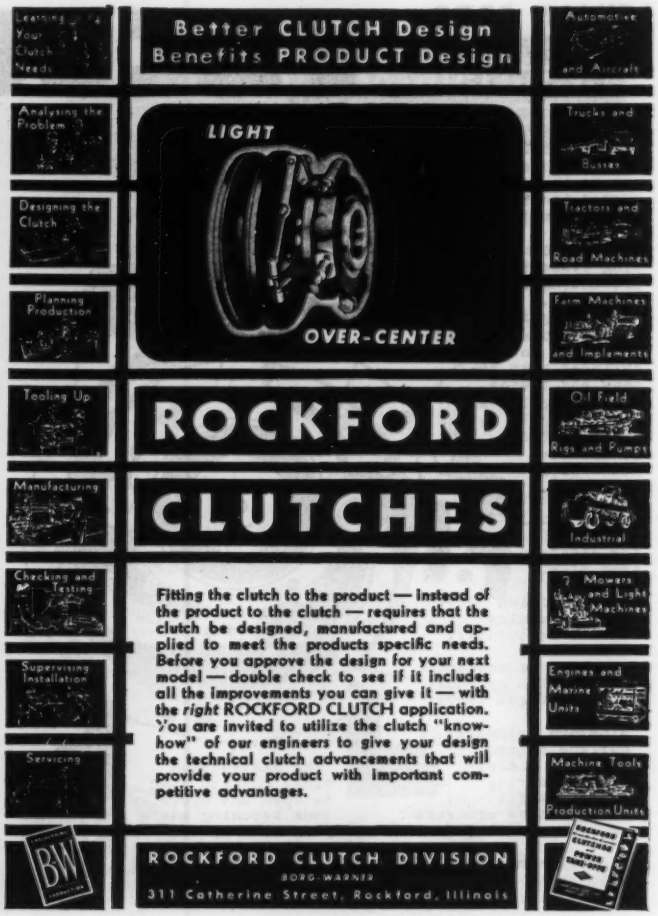
When ordering centrifugal castings, specify "Chief Sandusky".

ON THE JOB—Pouring a "Chief Sandusky" Centrifugal Casting.

CHIEF SANDUSKY *CENTRIFUGAL CASTINGS*

SANDUSKY FOUNDRY AND MACHINE CO. SANDUSKY OHIO, U.S.A.


Here—
unusual springs
are the
usual thing
Combinations of Assemblies as well as intricately formed flat and coiled springs
BGR
BARNES-GIBSON-RAYMOND
DIVISION OF ASSOCIATED SPRING CORPORATION
6400 MILLER AVE., DETROIT 11, MICHIGAN
COOK PLANT • ANN ARBOR, MICHIGAN


Better CLUTCH Design
Benefits PRODUCT Design
Learning Your Clutch Needs
Analyzing the Problem
Designing the Clutch
Planning Production
Tooling Up
Manufacturing
Checking and Testing
Supervising Installation
Servicing
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Trucks and Buses
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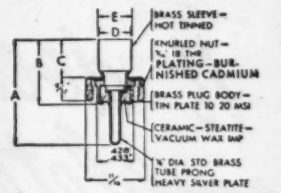
CLUTCHES
Fitting the clutch to the product — instead of the product to the clutch — requires that the clutch be designed, manufactured and applied to meet the products specific needs. Before you approve the design for your next model — double check to see if it includes all the improvements you can give it — with the right ROCKFORD CLUTCH application. You are invited to utilize the clutch "know-how" of our engineers to give your design the technical clutch advancements that will provide your product with important competitive advantages.
ROCKFORD CLUTCH DIVISION
BORG-WARNER
311 Catherine Street, Rockford, Illinois

PUMP SPACE LIMITED?
Install an IMO
• The capacity of the IMO is increased by high speed operation. This compact pump can be directly connected to the driving machine without bulky speed reduction gearing.
• IMO Pumps can be furnished for practically any capacity and pressure required for oil, hydraulic-control fluids and other liquids.
Send for Bulletin 1-146D
IMO means I MOVE OIL
IMO PUMP DIVISION of the
DE LAVAL STEAM TURBINE CO.
TRENTON 2, NEW JERSEY

Ideal for
ANTENNA CONNECTIONS
PHOTO-CELL WORK
MICROPHONE CONNECTIONS



SUPPLIED IN 1 & 2 CONTACT TYPES

JONES
SHIELDED TYPE
PLUGS & SOCKETS

LOW LOSS PLUGS AND SOCKETS FOR HIGH FREQUENCY CONNECTIONS

For quality construction thruout, and fine finish, see diagram above.

101 Series furnished with ¼", .290", 5/16", ⅜", or ½" ferrule for cable entrance. Knurled nut securely fastens unit together. Plugs have ceramic insulation; sockets bakelite. *Assembly meets Navy specifications.*

202 Series Phosphor bronze knife-switch type socket contacts engage both sides of flat plug contacts—double contact area. Plugs and sockets have molded bakelite insulation.

For full details and engineering data ask for Jones Catalog No. 17.

JONES MEANS *PROVEN QUALITY*

P-202-CCT

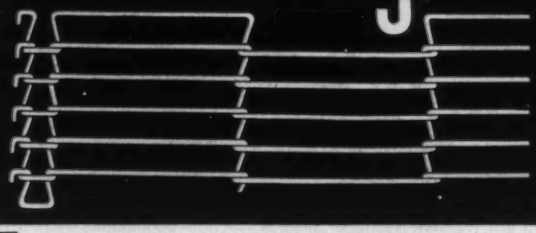
P-101-¼

S-202-B

S-101

HOWARD B. JONES DIVISION
Cinch Mfg. Corp.
2460 W. GEORGE ST. CHICAGO 18, ILL.

EASES CONVEYING 5 WAYS



Flat-Flex Wire Conveyor Belting is easy to
INSTALL — DRIVE — GUIDE — CLEAN — REPAIR

Positive, accurate drive assured by drive roll . . . no slipping. *Flat-Flex interlocked wires* easily lace together...make a uniformly flat belt...simplify installation and maintenance. *Extreme flexibility* permits turning on diameter as small as ⅛".

85% open Flo-Thru mesh allows free flow of air or fluids through belt.

Write Today for complete information!

750 MAIN STREET, CAMBRIDGE 39, MASS.

HOW TO SELECT *the Right* UNIVERSAL JOINT

Universal joints perform various functions in a wide variety of applications — from heavy duty power transmission to high or low speed light duty installations. Selection of the *right* joint for the job is important.

Either the Curtis Standard — available in 14 sizes, from ⅜" O.D. to 4" O.D., single or double — or the *new* Curtis Ball-Type in 4 sizes, from ½" O.D. to 1-¼" O.D., will enable you to specify the correct size and strength of joint to secure the most economical and trouble-free installation.

For heavy-duty jobs specify Curtis Standard Joints — made of alloy steel throughout with each part heat treated and ground for maximum strength, long life and accuracy.

For light-duty work specify Curtis Ball-Type Joints — with bronze center ball and steel forks with center pins of heat treated, centerless ground steel.

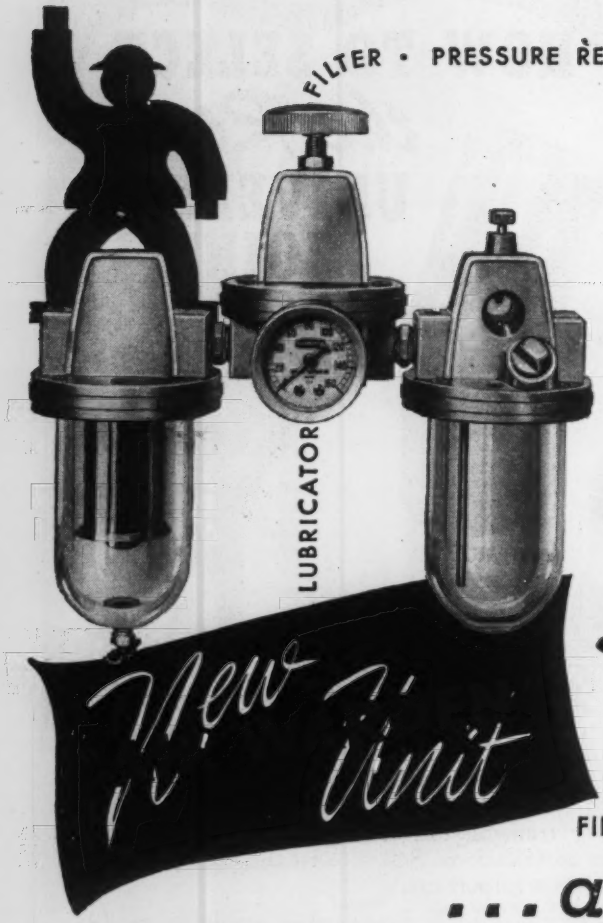
Select the RIGHT joint for your particular purpose from the data shown below —

Cat. No.	Type	O. D.	Overall Length	Breaking Loads: Static Torque in. lbs.	Breaking Loads: Tensile Load Pounds
C-642	Std.	½"	2"	340	1000
CS-42	Ball	½"	2"	170	720
C-644	Std.	¾"	2-11/16"	1300	2800
CS-44	Ball	¾"	2-11/16"	650	2000
C-646	Std.	1"	3-⅜"	2500	5150
CS-46	Ball	1"	3-⅜"	1250	3600
C-648	Std.	1¼"	3-¾"	5000	7200
CS-48	Ball	1¼"	3-¾"	2500	4950

All Curtis Joints can be furnished with hubs machined to your specifications. Drawings should accompany inquiry if possible.

For complete engineering data and drafting templates write Dept. B

CURTIS UNIVERSAL JOINT CO. INC.



It does the complete JOB!

1. **FILTERS AIR**—This new Hannifin unit for conditioning compressed air gives you everything you want for protection and control of air operated equipment. Micronic type filter removes grit, dirt, and scale, as well as moisture and emulsified oil.

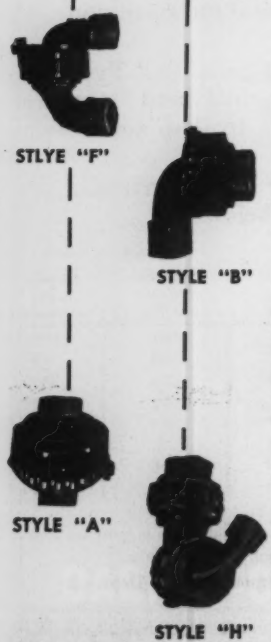
2. **REGULATES PRESSURE**—Set the pressure where you want it and the Hannifin *"Air Warden"* regulator does the rest! No danger of pressure build-up. Easy to "back off." Quick acting, durable, and dependable.

3. **LUBRICATES**—The modern way to lubricate air operated cylinders and tools. Atomizing type lubricator adds right amount of oil when air flows. Ask for information about the complete unit. Filters, regulators, and lubricators also available separately. Sizes ⅜" and ½". HANNIFIN CORPORATION, 1101 SO. KILBOURN AVE., CHICAGO 24, ILLINOIS.

FILTER • PRESSURE REGULATOR • LUBRICATOR • FILTER

. . . a HANNIFIN Product

The Strength of PIPE
The Flexibility of HOSE . . .
FLEXO JOINTS



Wherever a flexible or swing joint is needed—you can count on Flexo Joints to convey pressures from gravity up—safely and dependably.

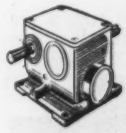
For standard pipe sizes from ¼" to 3", Flexo Joints offer unrestricted flow through 360°. Made of just four simple parts, they assure extra long wear, low maintenance cost.

Learn how FLEXO JOINTS can be used in your equipment. Write for details.

FLEXO SUPPLY COMPANY, INC.
4648 Page Blvd. **St. Louis 13, Mo.**
In Canada: S. A. Armstrong, Ltd. 115 Dupont St. Toronto 5, Ont.

Ask for 24-page catalog "M-4", containing technical data on Euclid Speed Reducers.

. . . . IT COSTS NO MORE TO GET ALL THE ADVANTAGES OF *Euclid Universal* DESIGN!



Double reduction gear unit.

Whether in standard or special design, Euclid Universal Speed Reducers offer unique, proven advantages: (1) removable base plate making possible various shaft positions; (2) gears with 20° pressure angle, increasing torque and horse-power capacity; (3) streamlined design, eliminating protruding bolts and stubs; (4) all shafts Timken mounted to withstand load; (5) oversize shafts for special applications.

Write on your letterhead for valuable catalog.

SUCCESSOR TO EUCLID MACHINE & TOOL COMPANY

EUM EUCLID UNIVERSAL MACHINE, Inc.
15002 WOODWORTH ROAD • CLEVELAND 10, OHIO
2-WAY UNIVERSAL SPEED REDUCERS

Is Formica for you?

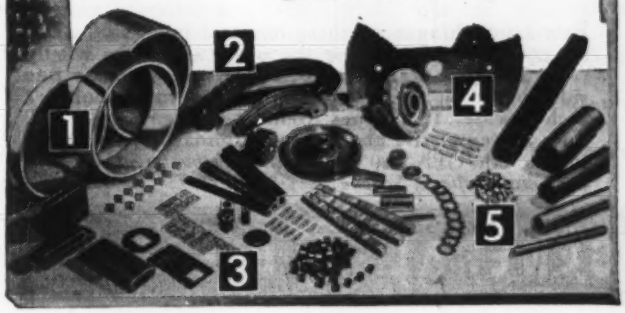
Formica Parts are at work in every type of Industry. Just to stimulate your own creative thinking on how Formica fits your production picture, some of the parts illustrated are identified here:

1. Tubing for Electrical Insulation.
2. Cable Guides used on Elevators.
3. Contact Post Insulators for Automotive Generator Cutouts.
4. Condenser Spacer, Aviation Industry.
5. Washing Machine Silencer Spring Buttons.

Data on Formica

Let us know how you are considering Formica. It can be custom built to meet your requirements. "Data on Formica" and typical samples are available. Help us help you. Write FORMICA, 4545 Spring Grove Ave., Cincinnati 32, Ohio.

Productive FORMICA at Work in Industry



Cleans, Good Gears Only

TO MEET Your PARTICULAR NEEDS

- ★ SPUR
- ★ BEVEL
- ★ HELICAL
- ★ SPLINE
- ★ WORM
- ★ SPROCKET
- ★ INTERNAL
- ★ ZEROL
- ★ CONIFLEX
- ★ SPIRAL BEVEL

Each Cincinnati Gear is made to fit a particular requirement from job specifications.

Cincinnati Gears, Good Gears Only, have the built-in accuracy and precision that make possible outstanding performance records.

Let Cincinnati Gears, Good Gears Only, work for you . . . they will meet your every job requirement.

THE CINCINNATI GEAR COMPANY

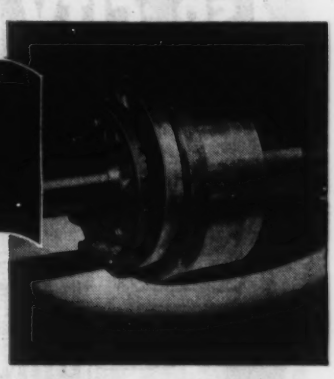
"Gears : Good Gears Only"

Wooster Pike and Mariemont Ave. ★ Cincinnati 27, Ohio

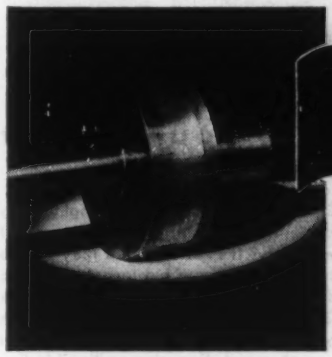
HILLIARD *Clutches*

FOR POWER CONTROL DESIGNS

HILLIARD SINGLE REVOLUTION CLUTCH



Unequalled for accurate control of intermittent machine operations — cutting, punching, and packaging. Gives closer tolerances to cut-off, stamping, shearing, and similar machines. Completely automatic; manual, mechanical, or electrical control.



HILLIARD OVER-RUNNING CLUTCH

Hilliard Over-Running Clutches and Couplings are automatic in operation. They are unexcelled for automatic two-speed drives, dual drives, stand-by drives, and for allowing machinery to "coast" after drive stops. Excellent as fixed or infinitely adjustable ratchets.

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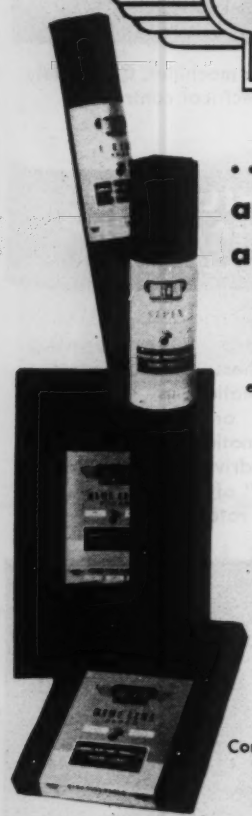

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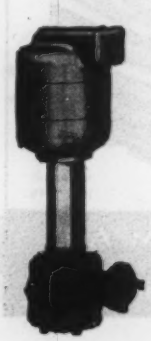

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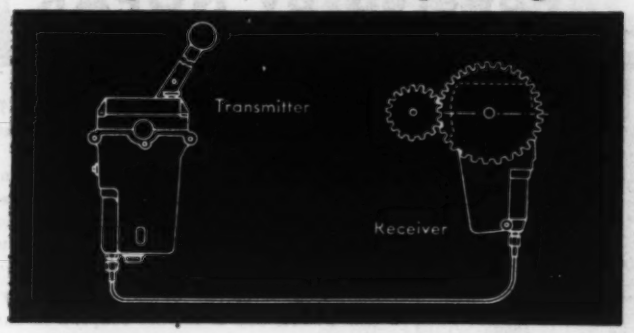

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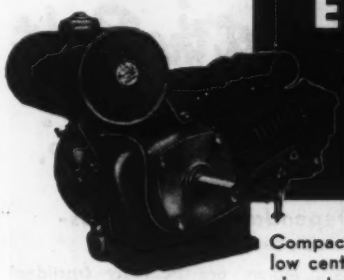

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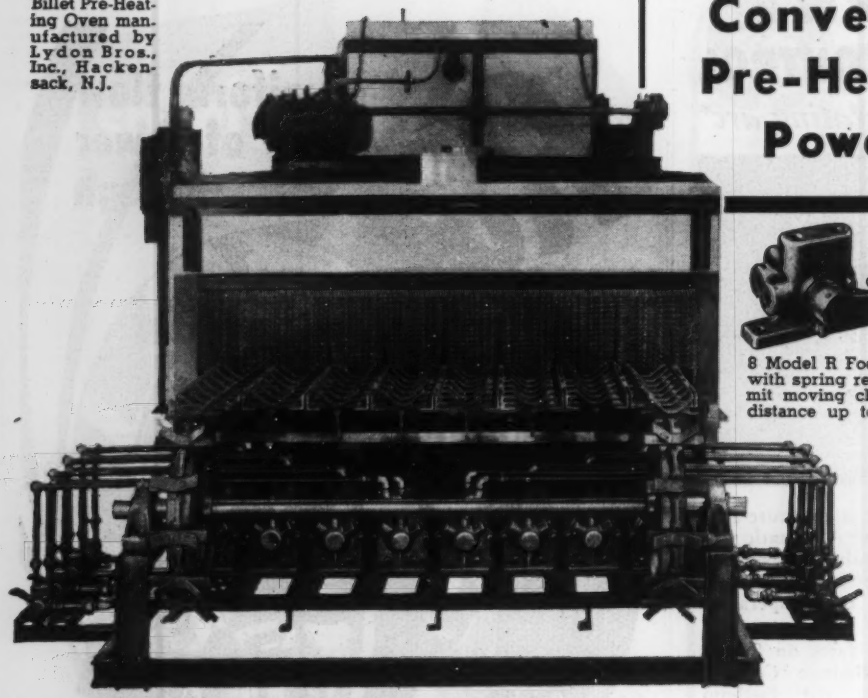
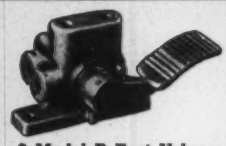
End view of Billet Pre-Heating Oven manufactured by Lydon Bros., Inc., Hackensack, N.J.



Conveyor Chains on Pre-Heating Ovens are Powered by NOPAK



8 Model R Foot Valves, with spring return, permit moving chains any distance up to 30".

Lydon Bros., Inc., Hackensack, N. J. . . . designers and manufacturers of industrial ovens and dryers . . . employ 8 NOPAK Model A Air Cylinders controlled by 8 NOPAK Model R Foot Valves in this Billet Pre-heating Oven, to actuate the conveyor chains which feed billets into the oven.

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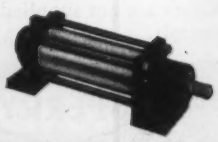

NOPAK Model A Air Cylinders like this, with 30" strokes, are used on the Lydon Bros. Oven.

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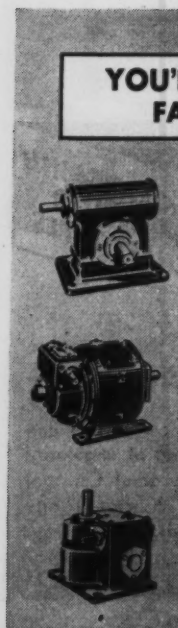

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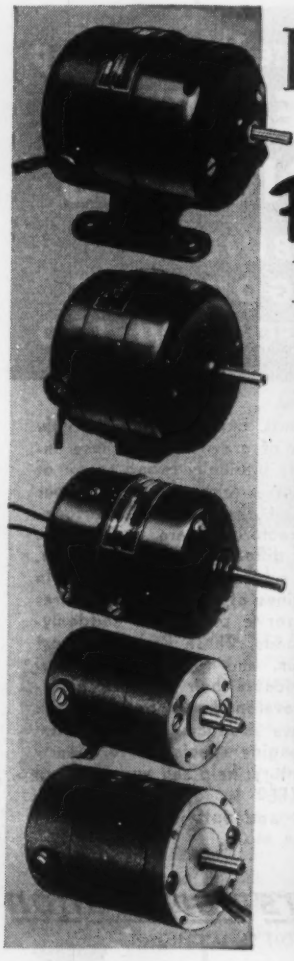

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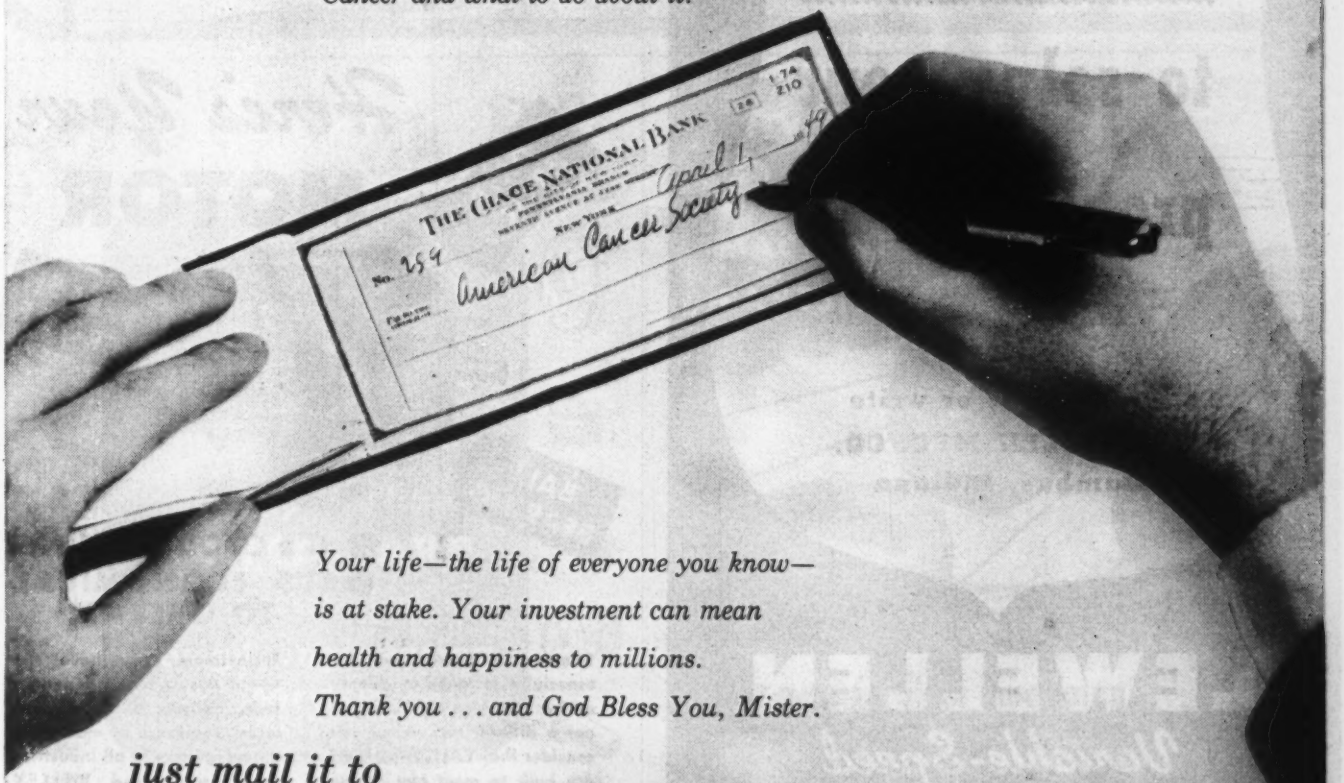

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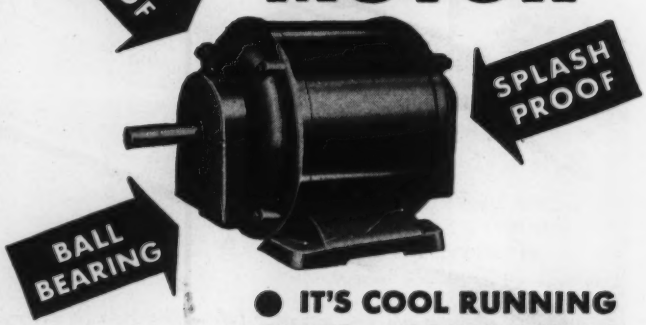

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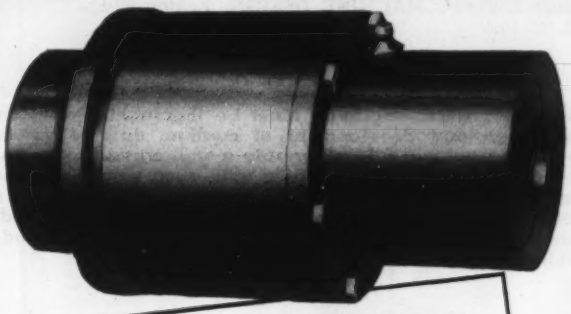

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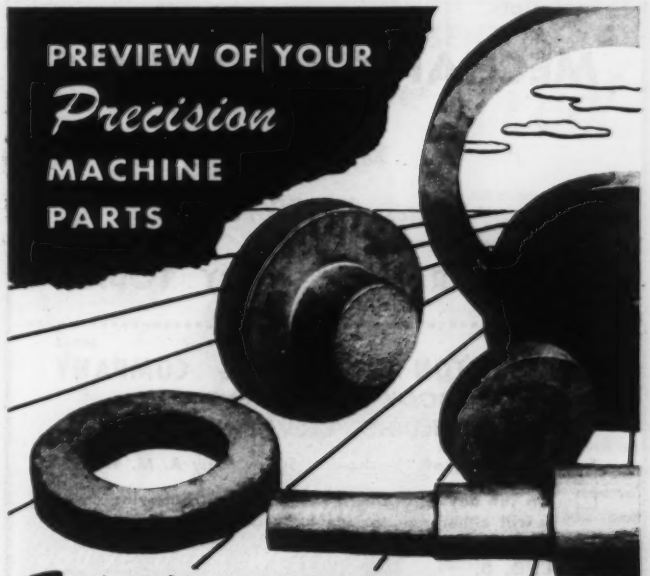

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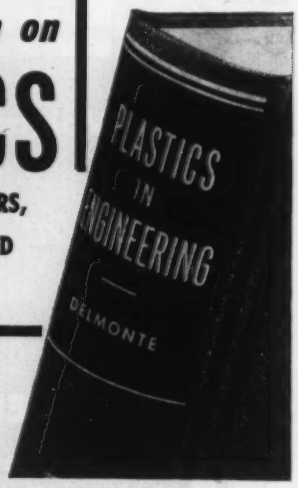

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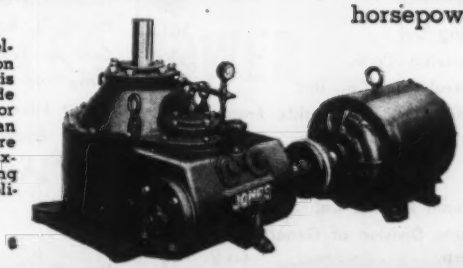

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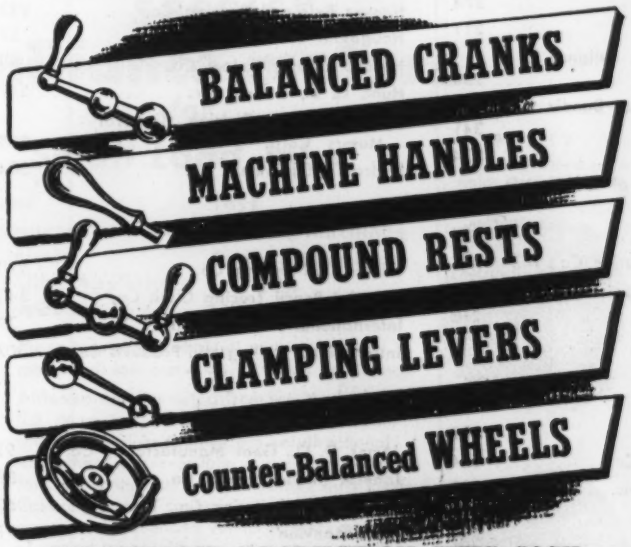

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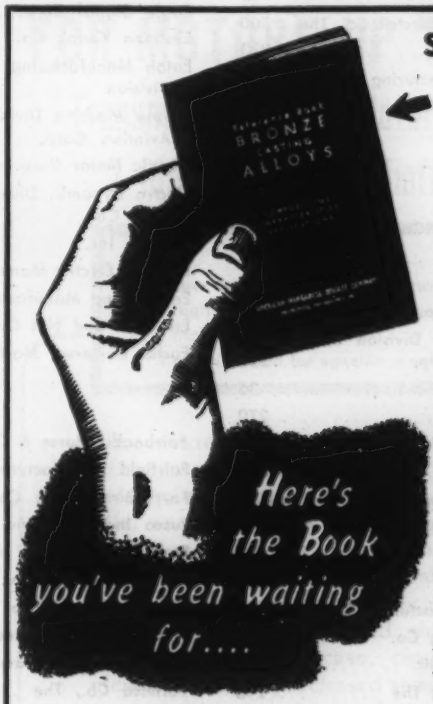

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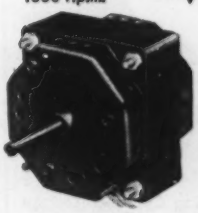

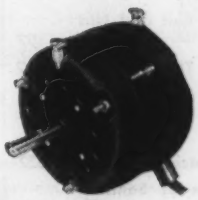

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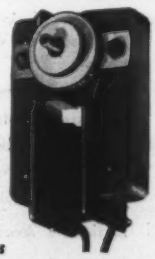

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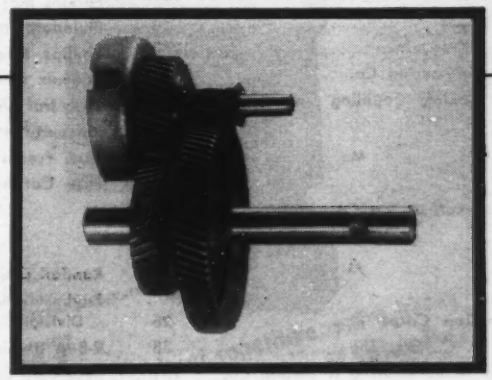

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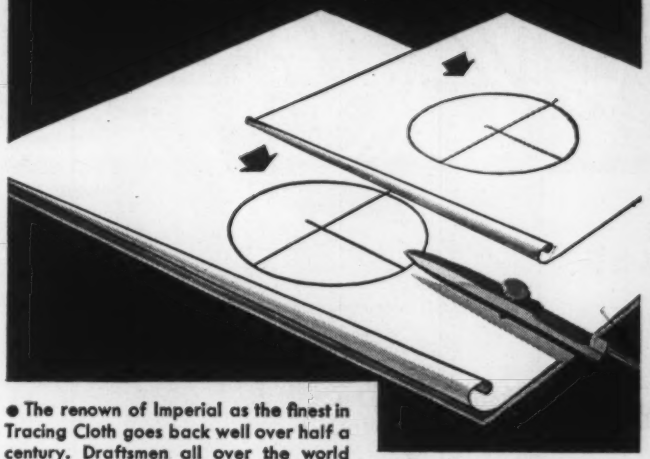

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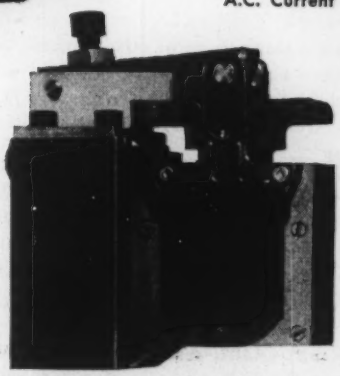

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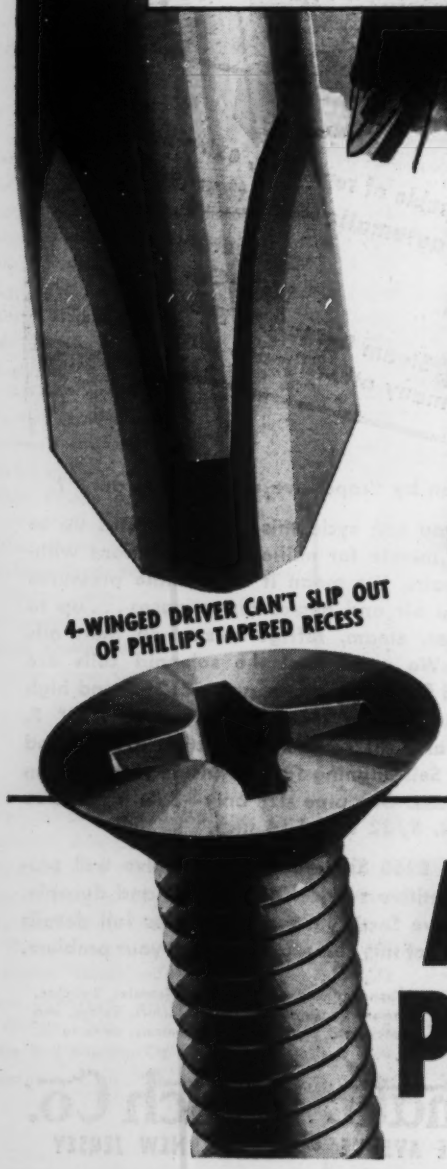

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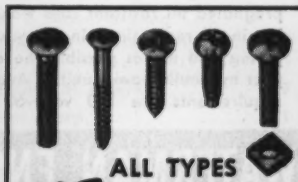

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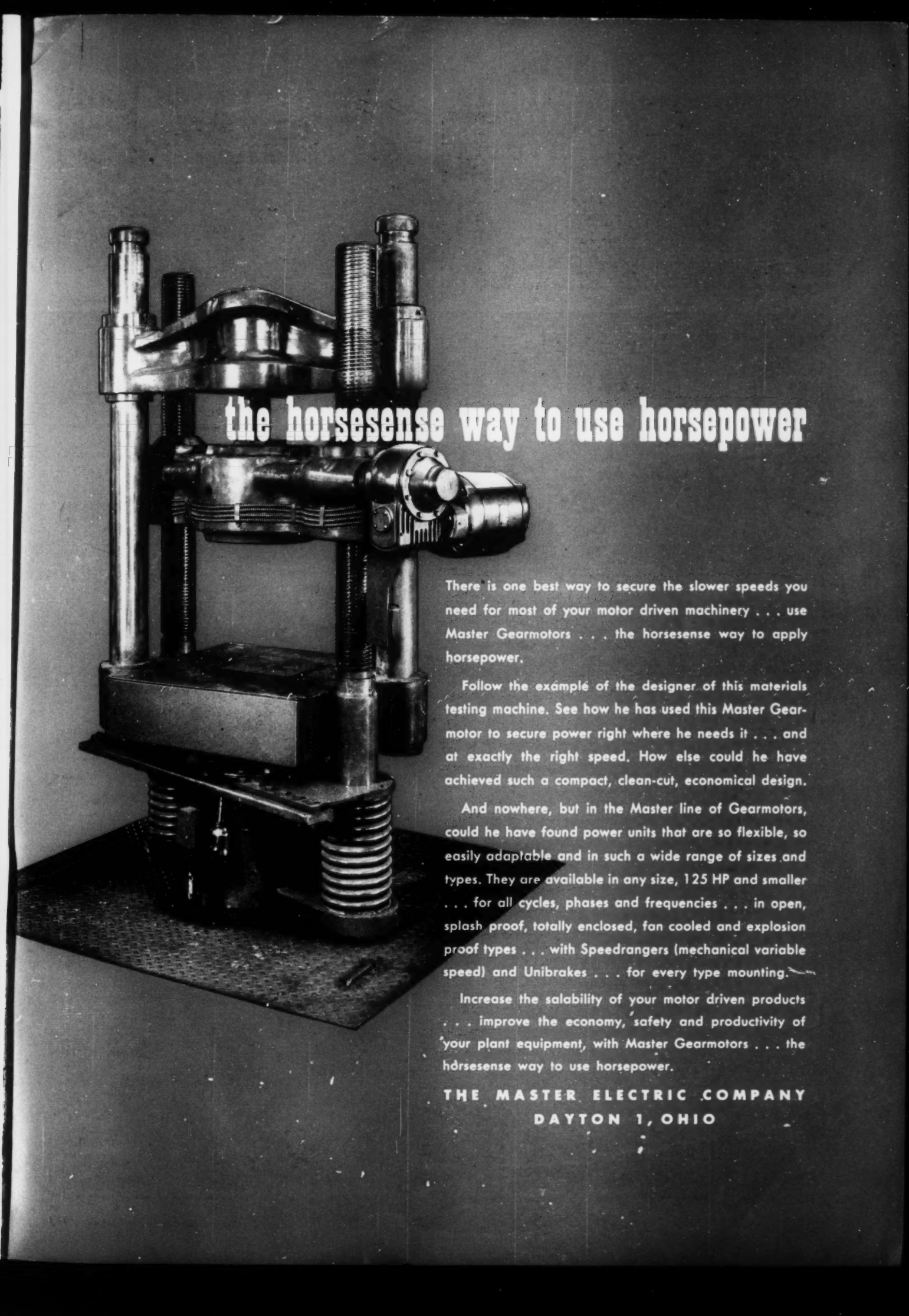

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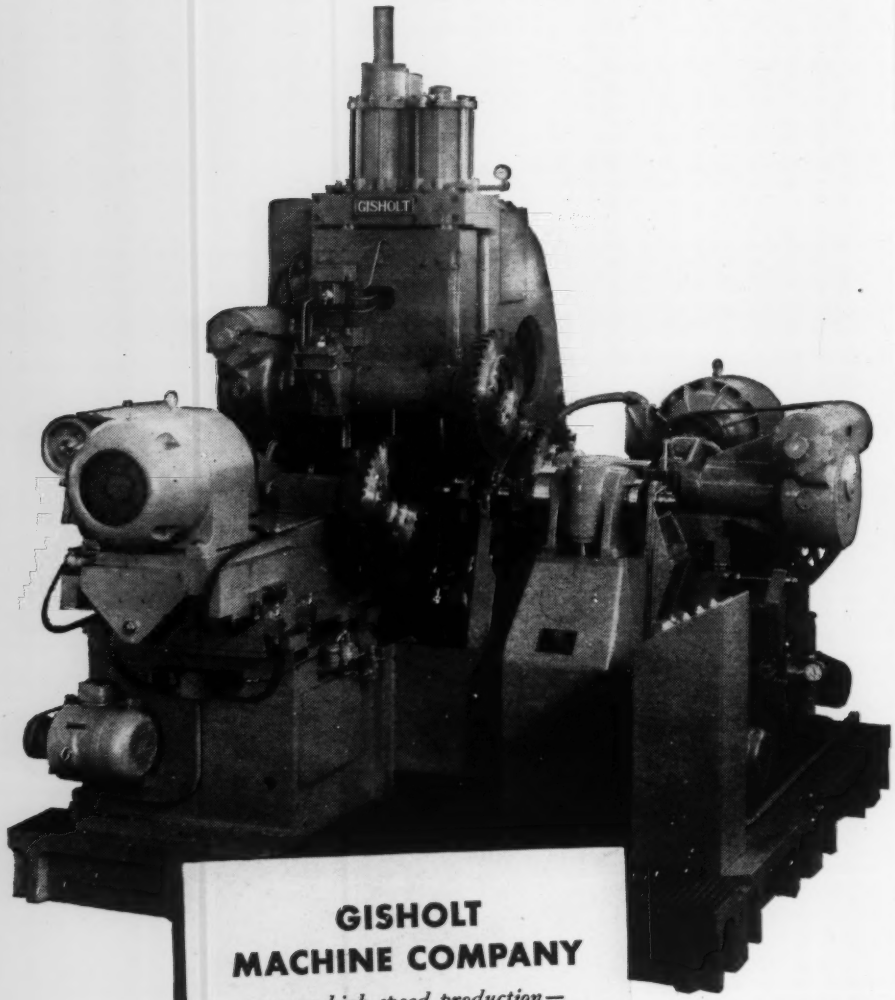

GISHOLT MACHINE COMPANY

assures high speed production—maintains accuracy by mounting spindles and headstocks of this Crankshaft Turn Mill on Timken tapered roller bearings.

FOUR throws of a typical V-8 crankshaft machined simultaneously in only 2 minutes—floor-to-floor time! That's the performance automobile manufacturers can expect with this Gisholt Crankshaft Turn Mill.

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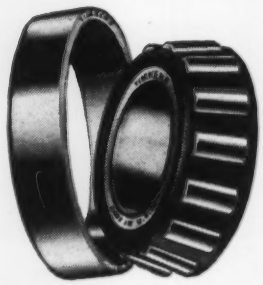

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